SCREENING LEVEL HUMAN HEALTH AND AGRICULTURAL RISK ASSESSMENT
San Juan River and Lake Powell
Gold King Mine Incident
Utah

Prepared for:

Utah Department of Environmental Quality
Division of Water Quality

Prepared by:

Tetra Tech, Inc.
10711 Red Run Blvd., Suite 105
Owings Mills MD, 21117

Submission Date: January 31, 2018

Table of Contents

1 INTRODUCTION ... 1

1.1 Objectives of the Human Health and Agricultural Screening Level Risk Assessment ... 2

1.2 Report Organization ... 4

2 PROBLEM FORMULATION, CONCEPTUAL SITE MODEL, AND TOXICITY EVALUATION ... 6

2.1 Data Evaluation ... 6

2.2 Potential Exposure Pathways and Conceptual Site Model ... 7

2.3 Toxicity Assessment ... 8

3 HUMAN HEALTH SCREENING LEVEL RISK ASSESSMENT ... 10

3.1 Methodology ... 10

3.2 Screening Levels ... 12

3.3 Risk Characterization ... 13

4 AGRICULTURAL SCREENING LEVEL RISK ASSESSMENT ... 16

4.1 Methodology ... 16

4.2 Comparison of Surface Water to UDEQ Agricultural Standards and Screening Values ... 18

4.3 Evaluation of Soil Concentrations from Use of SJR Water for Irrigation ... 19

4.4 Agriculture Risk Characterization ... 23

5 UNCERTAINTIES ... 26

6 RISK SUMMARY ... 28

6.1 Human Health Risk Assessment ... 28

6.2 Agricultural Risk Assessment ... 28

7 RECOMMENDATIONS ... 30

8 REFERENCES ... 31

List of Tables

Table 1. Estimated mass of metals delivered to the Animas River from the Gold King mine release

Table 2. Summary of Maximum Surface Water Dissolved and Total Metals Concentrations

Table 3. Summary of Maximum Sediment Concentrations
Table 4. Toxicity Values for the Human Health Risk Assessment
Table 5. Toxicity-Based Screening Values for the Agricultural Risk Assessment
Table 6a. Screening Values for Dissolved Metals Concentrations in Surface Water.

Table 6b. Results of Screening of Dissolved Metals Concentrations in Surface Water.

Table 7a. Screening Values for Total Metals Concentrations in Surface Water (Continued).

Table 7b. Results of Screening of Total Metals Concentrations in Surface Water.

Table 8a. Screening Values for Assessment of Sediment Concentrations

Table 8b. Results of Comparison of Sediment Concentrations to Screening Values.

Table 9. Hazard Values Calculated for Ingestion of Fish Tissue.

Table 10. Metals Accumulation in Soils

Table 11. Metals Accumulation in Plants and Comparison to Benchmarks

Table 12. Metals Accumulation in Cattle and Comparison to Benchmarks

Table 13. Metals Accumulation in Sheep and Comparison to Benchmarks

Table 14. Human Ingestion of Plants and Comparison to Risk-based Screening Values.

Table 15. Human Ingestion of Beef and Comparison to Risk-based Screening Values.

List of Figures

Figure 1. Sampling locations
Figure 2. Conceptual Site Model for the San Juan River and Lake Powell related to the Gold King Mine Incident

Lists of Attachments

Attachment 1. Bioaccumulation Factors for Beef and Plants
Attachment 2. Risk-Based Screening Levels for Ingestion of Beef and Produce

1 INTRODUCTION

On behalf of Utah Department of Environmental Quality (DEQ), a Screening Level Human Health and Agricultural Risk Assessment (SLRA) was completed for the San Juan River and Lake Powell with respect to potential human health and agricultural impacts from the Gold King Mine (GKM) release in August 2015 (Figure 1). During a United States Environmental Protection Agency (USEPA) removal assessment on August 5, 2015, approximately three million gallons of acid mine water containing mine waste sediments and heavy metals was released into Cement Creek, a tributary of the Animas River. The release flowed downstream as an orange-colored plume that became diluted as the Animas River joined the San Juan River by water releases from the Navajo Lake Dam (USEPA 2016).

This report presents the purpose, methods, and results of the SLRA, which includes an exposure assessment, toxicity assessment, and risk characterization. The SLRA serves as a screening, which is designed to conservatively estimate the potential risks associated with exposure to water and sediment of the SJR due to the release of contaminants in the GKM incident. The SLRA was completed in accordance with the USEPA guidance for human health risk assessment under the Comprehensive Environmental Response, Compensation and Liability Act (specifically, the USEPA's Risk Assessment Guidance for Superfund 1989).

The San Juan River flows from the Colorado border in southeast Utah and terminates in Lake Powell in the south central portion of the state. The San Juan River flows through San Juan County Utah and is surrounded by shrub lands, deserts and forested areas (Figure 1). Other land uses in the surrounding area include agriculture, mining, and residential development. The San Juan River was exposed to the plume of the GKM in August 2015. Based on USEPA's 2017 fate and transport analysis report, *Analysis of the Transport and Fate of Metals Released from the Gold King Mine in the Animas and San Juan Rivers* (www.epa.gov/goldkingmine/fate-transport-analysis), the GKM plume in the SJR entered Utah on August 8, 2015 and entered Lake Powell on August 14, 2015. The known composition of the potential contaminants in the GKM plume were included in USEPA's 2017 report and are shown in Table 1. The identified constituents included aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc, sulfate, chloride, fluoride, and nitrate as nitrogen. These constituents were evaluated in the surface waters and sediments of the Utah portion of the SJR using data collected prior to and after the GKM plume entered Utah to determine if there was an increased level of risk associated with the GKM plume. Risks were also evaluated in association with each sampling location from the Colorado border to Lake Powell.

The SLRA applies conservative assumptions to evaluate the potential risks to humans and agricultural receptors, under a range of relevant scenarios. A finding of potential risk in this SLRA does not necessarily indicate actual risks to humans, livestock or crops. Such a result may necessitate further evaluation and use of site-specific exposure data to address both the uncertainties resulting from the default conservative assumptions used to evaluate risk and to develop a more accurate assessment of risk. Given the conservative assumptions used in the SLRA a finding of little or no potential for risk would provide assurance that human health and agricultural receptors are unlikely to be adversely affected by constituents present in the sediments, surface water, or as accumulated in soil. The decision to proceed to additional assessment is part of risk management.

1.1 Objectives of the Human Health and Agricultural Screening Level Risk Assessment

The overall objective of the human health and agricultural SLRA is to identify and characterize current and potential threats to the human and agricultural receptors from constituents in surface water and sediment. For the purposes of this assessment, all constituents were considered contaminants of potential concern (COPC) and were retained in the SLRA. The functions of the SLRA are to:

1) Document whether actual or potential risks exist;
2) Identify which contaminants pose a risk; and
3) Generate results to be used in evaluating the need for further evaluation, further monitoring, or remediation.

Using these goals, the SLRA was divided into two sections, the human health screening level risk assessment, assessing direct exposure to surface water and sediment by humans, and the agricultural screening level risk assessment, to assess risks to agricultural receptors and persons ingesting livestock or crops irrigated with water from the SJR. The objectives of the SLRA are to:

1) Characterize the potential exposure pathways;
2) Identify the appropriate exposure concentration for each COPC in each applicable media (surface water, sediment, soil and biota); and
3) Assess potential risk from the COPCs to each receptor.

Although the guidance documents referenced below were developed for human health risk assessment, the process is an applicable and efficient way to assess risks to agricultural receptors. The same methodology was applied to the agricultural risk assessment as there is currently no standard guidance for assessing risks to agricultural receptors. This SLRA incorporates the latest available guidance and concepts on risk assessment, including:

- USEPA. 1986. *Methods for Assessing Exposure to Chemical Substances, Volume 8: Methods for Assessing Environmental Pathways of Food Contamination*. Perwak, J., Ong, J.H., R. Whelan. EPA 540/5-85-008. U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC.
- USEPA. 1989. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540-1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 1991. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remedial Goals)*. Interim. EPA/540/R-92/003. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 2017. *Regional Screening Levels (RSLs), User's Guide (June 2017)*. https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-June-2017.

In addition, the following documents were used to evaluate risks to agricultural receptors in the absence of formal risk assessment guidance for these receptors:

- Utah Water Quality Standards (Numeric Criteria) (UAC R317-2-14_ for San Juan River Users [dissolved metals]
- National Resource Conservation Service (NRCS). 2003. National range and pasture handbook. U.S. Department of Agriculture.
- Raisbeck MF, B Wise, JR Zygmont, MA Smith, and CM Tate. 2011. *Water Quality for Wyoming Livestock and Wildlife: Final Report*. .
- Efroymson RA, ME Will, GW Suter III, AC Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.

The SLRA was performed to provide a conservative estimate of potential risk, using risk-based concentrations. The screening level risks have been calculated based on all potentially complete pathways for all receptors and conservative exposure assumptions, including evaluation of the fish ingestion pathway and ingestion of homegrown crops and livestock.

1.2 Report Organization

This Report is organized to present the methods, assumptions, and results used to complete this SLRA and make recommendations. This SLRA Report is organized as follows:

- Section 1.0 – Introduction. Provides description of the SLRA process as well as the San Juan River and Lake Powell study area, and outlines the report organization.
- Section 2.0 – Problem Formulation. Describes the environmental setting of the study area, the available analytical data, potential exposure pathways and development of the conceptual site model (CSM), and summarizes the human health toxicity values Agricultural screening values and toxicity reference values (TRVs) are also provided.
- Section 3.0 – Human Health Screening Level Risk Assessment. Describes the methods and results of the assessment of potential risks to human health from site-related COPCs.

- Section 4.0 – Agricultural Screening Level Risk Assessment. Describes the methods and results of the assessment of agricultural risk based on a simplistic food-web model, using calculated soil concentrations based on use of SJR water for irrigation and livestock water supply.
- Section 5.0 – Uncertainties Associated with the Human Health and Agricultural Risk Assessments. Identifies and discusses the sources of uncertainty in the risk assessments and evaluates their potential impacts on results.
- Section 6.0 –Risk Summary. Summarizes the conclusions of the risk assessments from Sections 3 and 4.
- Section 7.0 – Recommendations. Provides recommendations for next steps.
- Section 8.0 – References. Lists all references cited in the report.

2 PROBLEM FORMULATION, CONCEPTUAL SITE MODEL, AND TOXICITY EVALUATION

Human health risk assessment is the scientific process of evaluating the toxic properties of compounds and the conditions of human exposure to determine the likelihood that an exposed population will be adversely affected. Following the risk assessment model presented by USEPA (1989), the approach to human health risk assessment includes the four following components: data evaluation and identification of COPCs, exposure assessment, toxicity assessment, and risk characterization. This assessment contains a complete screening level human health risk assessment, including documentation of all exposure assumptions and equations, toxicity values, exposure data, risk estimates, sources of uncertainty, data gaps, and conclusions and recommendations. Using the previously evaluated surface water and sediment data, exposure information, and potential toxicity, the SLRA provides an estimate of the potential for adverse health effects to humans or agricultural receptors and the need for any remediation or administrative or engineering controls.

2.1 Data Evaluation

Based on the known composition of the GKM release (Section 1.0 and USEPA 2016), COPCs have been identified as the suite of metals presented in Tables 2 and 3 for surface water and sediment, respectively. Table 1 contains the estimated amount of each metal that was released to the Animas River and may have transferred to the SJR. All of the COPCs have been included in this analysis. However, human health toxicity values are not available for calcium, magnesium, sodium, and potassium as these are essential human nutrients and are considered non-toxic. Therefore, while retained in the table for completeness, risks are not calculated for these COPCs. Similarly, sulfate, chloride, and nitrate are water quality indicators that are not included in the human health SLRA but are included in the agricultural risk assessments as these constituents can impact the health of livestock.

Data were evaluated in the Nature and Extent Memorandum (Tetra Tech 2017). Based on that evaluation, the use of the maximum detected concentrations in the SJR post-release have been used as the initial exposure concentrations. Background concentrations have not been used to select COPCs but are included in the data summary tables for reference. Figure 1 shows the sampling locations that correspond to the data presented in Table 2.

2.2 Potential Exposure Pathways and Conceptual Site Model

Exposure to contaminants can only occur if there is a complete pathway by which humans can be exposed to the affected food, sediment, or water; risks are calculated for completed exposure pathways. A fundamental principle in risk assessment is that a risk can only occur if there are links between sources of chemicals and human or, in this case, agricultural receptors (e.g., plants, animals).. Therefore, determination of complete exposure pathways and development of the CSM is the first part of an exposure assessment. The CSM for the human health and agricultural risk assessment includes sources, transport mechanisms, points of exposure, exposure pathways, and receptors that are included in the screening level analysis, shown in Figure 2. Water from SJR can be used for domestic purposes, and exposure routes to humans can also occur through recreational water use, such as wading, swimming, and boating which involves dermal exposure and incidental ingestion of water and sediment. Ingestion of fish (such as channel catfish) is considered a potentially complete exposure pathway. Occupational exposure of irrigation water and sediment to farmers and agricultural workers will also be considered along with the residential and recreational exposures.

To evaluate exposure through ingestion of fish, bioaccumulation factors (BAFs) available from EPA, Oak Ridge National Laboratory (ORNL), and peer-reviewed literature were used to estimate fish tissue concentrations in the ecological risk assessment. The total estimated fish tissue concentration from both surface water and sediment for each metal was used to estimate associated human health risk from ingestion of recreationally caught fish. The concentrations to assess fish ingestion were calculated in the ecological risk assessment (Tetra Tech 2018) and are conservative estimates that represent whole-body concentrations.

Dietary exposure pathways can represent a major exposure route to metals (USEPA 2007); these are assessed as part of the agricultural risk assessment. In the agricultural risk assessment, it is assumed that SJR water will be used to irrigate crops and pasture lands as well as to water livestock. Further, the crops are assumed to be food for livestock. The agricultural risk assessment therefore includes human ingestion of crops, livestock that have been fed crops grown on irrigated lands, and direct exposure to soils irrigated with SJR water for both livestock and humans. For the agricultural risk assessment, sampling results for both dissolved and total metals were used. Utah water quality standards are based on dissolved concentrations of metals and the sampling results for dissolved metals were compared to these standards. However, to be conservative, total metal sample results were used to assess an upper-bound value for accumulation of metals in soils, as it is possible that irrigation may occur with water that contains particulates and livestock may have direct access to waters of the SJR.

2.3 Toxicity Assessment

For the SLRA, existing risk-based screening levels that are applicable to the identified exposure pathways were used as well as additional screening concentrations to characterize potential hazards and evaluate compliance with Utah Water Quality Standards (WQS). These values will include Utah WQS, ATSDR health advisory concentrations for acute and chronic water intakes (ATSDR_2017), USEPA Regional Screening Levels (RSLs) for tap water (if applicable) (USEPA 2017), and maximum contaminant level (MCLs) (USEPA 2017). The risk based standards from USEPA and ATSDR for soil were used to assess direct exposure to sediment.

Table 4 presents the human toxicity values that were used for each evaluated COPC in the various screening levels. The same human toxicity values were contained in each EPA risk-based screening level used to assess risk (ATSDR screening values may use different toxicity values, as they assess subchronic exposures as well as chronic exposures). Most values can be found on the Integrated Risk Information System (IRIS, EPA 2018), although some values are provisional.

RSLs for residential exposure to soil, ingestion of tap water, and occupational exposure to soil were used in the human health and agricultural risk assessments. RSLs are risk-based screening levels developed by EPA for environmental media, and are based on reasonably conservative human exposure parameters and standardized toxicity values. RSLs for water assume ingestion rates typical of a residential water supply (tap water) as well as dermal exposure to water; these values incorporate exposures of children and adults. Soil RSLs estimate an acceptable concentration for daily exposure to soil under residential exposure assumptions, including exposures of children. In addition, soil RSLs based on an adult worker exposure were used in the agricultural assessment and are presented in Table 4. RSLs are calculated to be protective of chronic exposures to environmental media. For noncarcinogenic chemicals, the RSLs correspond to a hazard of 1.0 through all exposure pathways. For carcinogenic chemicals (in this case, arsenic) the RSL corresponds to a risk of 1E-6 (1 in one million).

RSLs do not include screening levels for fish, beef or produce intake. Biota screening values based on a farmer's ingestion of homegrown plants and beef were based on the toxicity values in Table 4 and were generated by an on-line calculator for this purpose (ORNL 2018). BAFs for plants, cattle, and sheep were also obtained from ORNL 2018. These chemical-specific values are provided in Attachment A and are used in Section 4. Fish ingestion was assessed using the toxicity values in Table 4 and a forward risk calculation, based on concentrations of metals in fish as calculated in the ecological risk assessment (details are provided in Section 3.1).

Toxicity reference values and screening levels for agricultural receptors are presented in Table 5. Several sources were used to identify screening values, with Utah Water Quality values being used first. Utah water quality standards are based on dissolved metals concentrations. However, other screening values are based on total metals concentrations and the exposure pathways identified are best assessed using total metals concentrations as it is assumed that agricultural exposure pathways to water may involve direct use SJR water without treatment or filtration.

3 HUMAN HEALTH SCREENING LEVEL RISK ASSESSMENT

A screening level risk assessment, presented in Tables 6 through 9, was conducted to assess potential human health risks and hazards from direct contact with SJR water and sediment. In addition, an evaluation of risks from ingestion of recreationally caught fish was conducted. Section 3.1 describes the methodology used for the human health SLRA and Section 3.2 presents the screening levels used for the SLRA. The risk characterization presented Section 3.3 describes the results of the human health SLRA.

3.1 Methodology

The SLRA compared the maximum sampling results to risk-based and regulatory screening levels. In the screening analysis, the maximum concentration for each COPC at the six surface water sampling locations were compared to the regulatory concentrations and RSLs (described in Section 2.3), and the ratios of those values summed to determine if total risk or hazard could exceed 1E-6 (carcinogenic risk) or 1.0 (non-carcinogenic hazard quotient). Similarly, maximum sediment concentrations were compared to RSLs for soils and to ATSDR values (acute and chronic EMEGs) (described in Section 3.2) to determine potential risk. The calculated risks were then summed and evaluated in light of risk criteria. The acceptable risk range for carcinogens is generally 1E-6 to 1E-4 (1 in one million to one in ten thousand risk of developing cancer), and risks below 1E-6 are considered insignificant. For noncarcinogens, the sum of hazard quotients is the hazard index, and a hazard index of 1.0 or less indicates little potential for adverse, noncarcinogenic health effects.

Although cancer risks and noncarcinogenic hazards are calculated using the RSLs, exceedances of other screening values and standards were also identified. Utah WQS for domestic water are presented in Table 6, as well as water quality standards for agricultural water uses. Screening levels for recreational exposure to water (UDEQ 2016) are presented in Table 7. Environmental screening values from the Agency for Toxic Substances and Disease Control were also included to assess potential health hazards associated with acute and sub-chronic exposures and are presented in Table 7. The ratio of the maximum measured concentrations to these screening levels were calculated, and used to estimate potential risk and hazard associated with exposure to SJR water and sediment using the following equation:

Risk (or hazard quotient) = C_{media} / SL

Where

C_{media} = Concentration in media (mg/kg or µg/L)

SL = Screening Level (mg/kg or µg/L)

A resulting value greater than 1 indicates that the COPC may pose an unacceptable risk (greater than 1E-6) or hazard quotient (1.0). Further, the risks and hazards were summed to evaluate whether the total risk or hazard presented by all COPCs exceeded acceptable levels.

In addition, an analysis of risks and hazards associated with ingestion of fish was conducted by calculating exposures rather than using a screening level. The risks and hazards were assessed separately from water ingestion, as ingestion of recreationally caught fish could occur without water or sediment ingestion. Fish ingestion was assessed using the assumption that one 8-ounce meal per week of fish was harvested from the San Juan River and consumed by an individual (i.e., 227 grams/7 days = 32 g/day of fish). This is consistent with recreational fishing and represents the likely exposure for the SJR. The following equation was used to estimate intake of fish:

Intake (mg/kg-day) = C_{fish} x IR fish x CF x EF x ED / (BW x AT)

Where

C_{fish} = concentration in fish (whole body) (mg/kg)

IR fish = Ingestion rate of fish (32 g/day, EPA 2011)

CF = Conversion factor (1E-6 kg/mg)

EF = Exposure Frequency (350 days/year)

ED = Exposure Duration (30 years)

BW = 80 kg (adult) (EPA 2011)

AT = 30 years for noncarcinogens, 70 years for carcinogens

This assessment was conducted using fish tissue concentrations as estimated in the ecological risk assessment (ERA) (Tetra Tech 2018) for those COPCs that could impact fish. The tissue concentrations represent whole-body estimates, which is a conservative value for the human health risk assessment as consumption of fillets is more typical than consumption of whole-body.

For the risk assessment of direct contact and ingestion was SJR water, total metals concentrations were used. While comparison to Utah WQS was conducted using dissolved metals concentrations (consistent with Utah regulations), exposure to waters of SJR could occur without filtration or treatment. For this reason, total metal concentrations were used for the assessment of risks and hazards.

3.2 Screening Levels

EPA RSLs were used to estimate risk and hazard from direct exposure to surface water and sediment. To be conservative, the RSLs based on residential exposure to soil were used to estimate risks associated with sediment exposure, and the tap water RSLs were used to assess risks from ingestion and dermal exposure to surface water. The RSLs include both adult and child exposures to soil and water and are conservative since exposure to the SJR water and sediment would be less than the 350 day per year exposure that is assumed in the derivation of the RSLs. As previously described, total metals concentrations measured in the SJR water were used for this comparison to account for both direct recreational exposure and use of the water as a domestic water source without filtration or treatment. Dissolved metal concentrations were used for comparison to Utah WQS.

ATSDR Environmental Media Guidelines (EMEGs) were also used for this assessment. These ATSDR guidelines represent the concentration of a substance in water, soil, or air that is not likely to cause adverse health effects when humans are exposed for a specified period of time (acute, intermediate, and/or chronic). Acute exposures are those 14 days or fewer; intermediate exposures are 15 days to 1 year, and chronic exposures are greater than 1 year. EMEG values are calculated using the minimum risk level (MRL), a toxicity benchmark developed by ATSDR. Additional details for derivation of EMEGs can be found in ATSDR's Public Health Assessment Guidance Manual (https://www.atsdr.cdc.gov/hac/phamanual/appf.html). Available chronic soil EMEG values for children and adults and acute soil EMEGs for children were compared to sediment concentrations. Additionally acute and intermediate values protective of children experiencing pica-type exposures (ingestion of unusually large quantities of soil or other materials) were compared to observed concentrations in SJR sediments. Chronic drinking water EMEGs for adults and children and acute EMEGs for children were compared to total metal concentrations measured in water.

Additional, recreational screening levels as presented in UDEQ 2016 were included in the evaluation. These screening levels are higher than the RSLs and EMEGs, as they do not include domestic use of water, but are protective of recreational uses of water (such as swimming) and of incidental ingestion.

3.3 Risk Characterization

Water. Using RSL, exposure to SJR water as a domestic water supply was assessed. Using dissolved metals concentrations (Table 6b) only lead exceeded the Utah Water Quality Standards for Class 1C (domestic water) water. The water quality standard is 15 µg/L and the maximum detected concentration in SJR samples was 15.7 µg/L. Comparison of agricultural water quality standards to the maximum detected concentrations showed that SJR samples exceeded long-term irrigation values for iron and manganese. The maximum dissolved concentration for iron was 3.3 times higher than the water quality standard for long-term irrigation, and for manganese, the SJR concentration was 2.1 times higher than the water quality standard.

The evaluation of total metal concentration in surface water (Table 7b) showed that while there were no exceedances of screening values for recreational water, eight metals are potential hazards when compared to EPA RSLs, six exceeded chronic EMEGs for children with four also exceeded chronic adult EMEGs, one exceeded acute EMEGs for children, and eight exceeded Utah's drinking water maximum contaminant levels or action levels. These exceedances are summarized below:

- RSL exceedances were identified for the following metals (maximum concentration, RSL shown, respectively): arsenic (45 µg/L, 0.052 µg/L), barium (20,000 µg/L, 3,800 µg/L), beryllium (53.3 µg/L, 25 µg/L), cadmium (24.9 µg/L, 9.2 µg/L), cobalt (254 µg/L, 6 µg/L), lead (369 µg/L, 15 µg/L,), thallium (2.59 µg/L, 0.2 µg/L), and vanadium (178 µg/L, 86 µg/L).

- Chronic EMEG exceedances for children are (maximum concentration, EMEG, shown respectively): antimony (6 µg/L, 2.8 µg/L,), arsenic (45 µg/L, 2.1 µg/L), barium (20,000 µg/L, 1,400 µg/L), beryllium (53.5 µg/L, 14 µg/L), cadmium (24.9 µg/L, 0.7 µg/L,), and nickel (375 µg/L, 140 µg/L).
- Chronic EMEG exceedances for adults were identified for (maximum concentration, EMEG shown, respectively): arsenic (45 µg/L, 7.8 µg/L;), barium (20,000 µg/L, 5,200 µg/L), beryllium (53.5 µg/L, 52 µg/L), and cadmium (24.9 µg/L, 2.6 µg/L).
- One metal exceeds the acute EMEG for children. The maximum copper concentration was 333 µg/L while the EMEG is 70 µg/L.
- MCL or action level exceedances were identified for antimony, arsenic, barium, beryllium, cadmium, chromium, lead, and thallium.

Sediment. The evaluation of sediment concentrations showed potential hazards associated with arsenic and aluminum when compared to residential soil RSLs and EMEGs (Table 8b). Arsenic exceeded EPA's Residential Soil RSL, with the highest measured concentration of arsenic of 2 mg/kg, while the RSL value is 0.68 mg/kg; the measured concentration corresponds to a cancer risk of 2.9E-6. Aluminum exceeded ATSDR's Intermediate EMEG for pica-exposed children, with the highest measured concentration of 6,140 mg/kg, while the Intermediate EMEG for pica is 5,300 mg/kg. No other measurements exceeded EPA's residential soil RSLs (noncarcinogenic or carcinogenic) or ATSDR EMEGs (child and adult chronic; child acute; child acute and intermediate pica). It should be noted that hazard was not assessed for calcium, magnesium, potassium, and sodium as these are considered essential human nutrients, are generally considered non-toxic, and no screening values were available. The only metal evaluated for carcinogenic risk was arsenic, as the other metals are not classified as carcinogenic or are carcinogenic only through the inhalation pathway. Chromium was evaluated as trivalent chromium in the risk assessment as the sampling results were reported as total chromium, and there is no indication that hexavalent chromium would be present (chromium in ore is typically hexavalent).

Fish Ingestion. The evaluation of fish ingestion showed that there are no hazards above 1.0 associated with this exposure pathway (Table 9). Thallium was associated with the highest hazard index at 0.115, and the total hazard index was 0.15, both of which are below the level of concern of 1.0. Conversely, lead in fish tissue was assessed for carcinogenic risk, using a toxicity value available from California EPA and used in ORNL 2018. This concentration in fish tissue was estimated to be 10.76 mg/kg, and even using intake values representative of a recreational fisher, the risk was 2.1E-4, which exceeds the acceptable risk range of 1E-6 to 1E-4. Note that this risk was calculated using a toxicity value from California EPA (CalEPA 2009) that is not necessarily accepted by USEPA as USEPA does not currently evaluate lead using typical risk assessment methodology. Lead is usually assessed used an integrated uptake biokinetic model that incorporates all lead exposure to a child and predicts a blood lead level that is evaluated for acceptability. As this assessment was focused only on ingestion of lead via fish tissue, a more simple calculation was used, consistent with other COPCs.

4 AGRICULTURAL SCREENING LEVEL RISK ASSESSMENT

Waters of the SJR may be used for agricultural irrigation and livestock watering as shown in the CSM, this creates the exposure pathways of:

(1) Direct ingestion of water by livestock,
(2) Uptake of metals by crops irrigated with SJR water,
(3) Ingestion of irrigated plants by livestock,
(4) Accumulation of metals in soils from irrigation water with subsequent incidental soil ingestion by livestock, or by residents of the land
(5) Ingestion of homegrown produce and meat grown by ranchers and residents.

Therefore, a screening assessment of the potential risks to crops and livestock from exposure to COPCs in surface water and its use for irrigation and livestock watering was conducted.

As there is no standard guidance for performing an agricultural risk assessment, the conventional risk assessment paradigm was used, including the following main components: 1) COPC selection and toxicity assessment (i.e., hazard identification and dose-response assessment of each COPC), 2) exposure assessment, and 3) risk characterization. These components are integrated into an approach that is similar to the screening assessments used for the ecological and human health receptors.

Section 4.1 describes the methodology and screening values used to assess agricultural risks from exposure to SJR water. Section 4.2 presents the methodology and result of the estimate of incremental soil concentrations from use of SJR water for irrigation, and the resulting concentrations in crops and livestock. Section 4.3 presents the risk assessment results for agricultural, residential, and occupational receptors.

4.1 Methodology

The constituents evaluated in the agricultural risk assessment are the suite of metals analyzed for in surface water, and are the same as those identified for the human and ecological risk assessments. Utah's agricultural water quality standards are based on dissolved concentrations of metals. However, this assessment included both a screening against Utah water quality standards using dissolved metals concentrations and an evaluation of risks and hazards associated with total metal concentrations in water. This is to address the possibility of unrestricted access to waters of SJR by livestock for watering, and to address the use of water for irrigating crops that are subsequently fed to livestock. The total estimated tissue concentration of cattle and sheep from water and irrigated pasture and crops was then used to calculate a potential dose to ranchers ingesting the livestock. This evaluation includes a discussion of potential increases in metal concentrations in soils over time. To assess potential hazards to livestock and crops, screening values presented in Table 5 were used for comparison to maximum concentrations of COPCs in water and incremental estimated concentrations in soil.

To assess exposure through food products, biota-specific screening levels based on ingestion of homegrown produce and livestock by a resident farmer were used for comparison to estimated concentrations of metals in the tissue of livestock and crops. These screening levels are based on the human toxicity values presented in Table 4.

As was conducted for the human health risk assessment, potential hazards to agricultural and human receptors was estimated from the ratio of the maximum measured concentrations to these screening levels were calculated, and used to estimate potential risk and hazard associated with exposure to SJR water and sediment using the following equation:

$$\text{Hazard} = C_{media} / SL$$

Where

C_{media} = Concentration in media (mg/kg or ug/L)

SL = Screening Level (mg/kg or ug/L)

A resulting value greater than 1 indicates that the COPC may pose an unacceptable hazard. Further, hazards (or risks for carcinogenic COPCs) were summed to evaluate whether the total hazard presented by all COPCs exceeded acceptable levels.

4.2 Comparison of Surface Water to UDEQ Agricultural Standards and Screening Values

As an initial assessment of the surface water data, the maximum detected dissolved concentration of each COPC was compared to water quality benchmarks.

As shown in Table 5, the primary benchmarks used were Utah's water quality standards for agricultural (Class 4) uses (Utah Administrative Code R317-2). Additionally, the agricultural screening values identified in *Utah's Longterm Monitoring and Assessment Plan* (UDEQ 2016) were used. These values are derived from the National Academy of Sciences (NAS) report *Water Quality Criteria 1972* and include benchmarks for livestock drinking water and irrigation water (NAS 1972). The benchmarks for irrigation water account for short-term (up to 20 years) and long-term (continuous) use of the waters and are protective for crops as well as livestock that consume irrigated crops.

Based on these benchmark values, all dissolved metals concentrations measured in surface water are below those of Utah Class 4 water quality standards. No exceedances of the benchmarks were observed. Ratios of the maximum concentrations to the benchmarks were calculated (water quality values are available for arsenic, cadmium, chromium, copper, lead, and selenium). All ratios were below 0.2, indicating measured concentrations are only 20 percent of the allowable concentration per regulation.

Using the UDEQ 2016 agricultural screening values, all COPCs were well below the benchmark levels as evaluated using dissolved metals concentrations, with the exception of iron and manganese. Both of these COPCs had maximum dissolved concentrations above the long-term irrigation benchmarks. Iron was more than three times the benchmark and manganese was more than twice its benchmark. This indicates that using water from the SJR, based on dissolved metals values, would be acceptable for use to irrigate crops with the exception of iron and manganese. The screening level of iron was set to a level that is not toxic to plants in aerated soil but can contribute to soil acidification and loss of essential phosphorus and molybdenum (EPA 2004). The screening level for manganese is based on its toxicity at low levels to plants in acidic soils (EPA 2004); Utah soils trend to be basic so manganese may not be problematic in this case.

4.3 Evaluation of Soil Concentrations from Use of SJR Water for Irrigation

In addition to exposures through ingestion of water, livestock can be exposed to COPCs through incidental ingestion of contaminated sediments or soil while foraging and to irrigated crops used as feed. Soil can accumulate contaminants through irrigation or from inundation by river water during spring runoff or storm events. These pathways were evaluated for their potential to adversely affect livestock health, and to assess accumulation of COPCs in livestock and subsequent exposure to humans through the harvesting of livestock.

For the exposure assessment, sampling data was used to estimate levels of exposure to crops and livestock through those pathways that are considered complete based on the CSM (e.g., irrigation of crops, livestock drinking water). Because the COPC concentrations are known to vary over time, particularly with spring runoff and storm events, the maximum detected COPC concentration in surface water was used as a conservative measure, and estimates of accumulation were based on incremental soil concentrations after one year of irrigation.

Estimate of COPC Concentrations in Soil. Potential soil concentrations were estimated by using the conservative assumption that all metal contained in the SJR water applied over a time period of 1 year would remain in the irrigated soil. The depth of the potentially impacted soil was set to 6 inches (0.15 m) to approximate a tillage depth for crops, and this value was used as a mixing zone depth for the metals in irrigation water that would accumulate in soils. Note that the estimate includes only the incremental increase potentially related to use of SJR water for irrigation and does not include background soil concentrations for these COPCs; thus, it is not an assessment of total risk but instead is an incremental risk estimate.

To estimate water usage, net irrigation values from Hill et al. (2011) for National Weather Service Monitoring Station Monticello 2E were used to approximate crop irrigation for alfalfa (beef) in San Juan County as this was the only location in San Juan County included in Hill et al. 2011. Alfalfa (beef) is alfalfa grown to be fed to cattle. The average annual irrigation rate of 18 inches water/acre per year was used (Table 16, Hill et al. 2011). This value converted to 0.0457 L/cm^2 per year, then multiplied by the amount of each metal in water (mg/L) and divided by 15 cm (6 inches) to estimate the average amount of the metal in surface soil, accounting for the tillage depth.

The value was converted to units of mg/kg by multiplying by the soil density (g/cm^3). Soils in southeast Utah are generally sandy-loam and for the purposes of modeling a concentration in soil from use of SJR water to irrigate soil, a soil density of 1.6 g/cm3 was used (USDA 2017). The equation is as follows:

Soil Concentration (mg/kg) = Cw x WC/D x SD

Where:

Cw = Concentration in water (mg/L)

WC = Water Consumption (average annual irrigation rate) (0.0457 L/cm2)

D = Depth of tillage (15 cm)

SD = Soil Density (kg/cm3)

The calculated amount of metal residual in soil was used to estimate the amount that may be taken up into plants and incidentally ingested by livestock while foraging. The concentrations were also used to assess direct exposures to soil by agricultural workers and residents of the ranch areas, assuming that the water could be used for landscape irrigation.

Estimates were based on 1 year of irrigation, as well as for 10 years and 100 years. While the estimates for 1 year were used to evaluated risks to livestock, crops, and humans, the accumulation values for 10 years and more provide an estimate of potential future soil concentrations to determine the acceptability.

The main crops grown in San Juan County are wheat and oats, which could be directly exposed to COPCs in surface water through irrigation with water from the SJR. For this assessment, however, alfalfa was used as an indicator crop because it requires more water than wheat or oats and is grown to be fed to livestock. The growing season in San Juan County averages about six months and varies somewhat depending on the location within the county. The average growing season at Mexican Hat runs from about April 24 to October 20. The maximum measured metal concentrations in surface water were conservatively selected as the exposure concentrations as insufficient data are available to calculate representative average concentrations over the growing season. The maximum concentration will also better represent elevated exposures that might occur for a short period of time following storm events and for longer periods of time during spring runoff (typically late April through May). The use of the maximum value is a reasonable estimate that indicates whether there is any risk and where future efforts for sampling should be focused.

Cattle are the main class of livestock in San Juan County; for this assessment cattle and sheep were evaluated because sheep are also a common livestock in this part of Utah. Cattle and other livestock could be directly exposed to COPCs in surface water through ingestion of drinking water supplied by the SJR. Similar to the approach for crops, the maximum concentration detected in surface water was used as a conservative measure to capture elevated exposures during spring runoff, and long-term (chronic) exposures represented by average concentrations over the year. Maximum measured water concentrations formed the basis of the exposure estimates through water intake and from soil and plants. Further, the plants irrigated by SJR water were assumed to be fed to livestock. It was also assumed that the livestock constituted a food source for the ranchers.

Exposure Assumptions. Therefore, as a conservative estimate of potential exposures and risks, the following assumptions were made to estimate potential exposures to COPCs through agricultural use of water:

1. **Exposure to livestock through drinking water.** Cattle and sheep were evaluated for direct ingestion of water used as a water supply to determine potential impacts to livestock health and to model intake by human receptors through consumption of beef. Sampling results for total metals in surface water in SJR were used to evaluate these exposures. Screening levels for livestock for total metals in drinking water were selected from Raisbeck et al. 2007, Raisbeck et al. 2011, and NRCS 2004. Risks to humans from drinking water were evaluated as described in Section 3.
2. **Exposure to crops through irrigation.** Water use for irrigation of crops (alfalfa) that allowed uptake to vegetation (subsequently fed to livestock) and deposition of metals in soils that could be ingested by livestock was evaluated. Alfalfa was selected for the evaluation because it has the representative water consumption for crops and the Utah Division of Water Rights uses alfalfa for administering water rights classification (Hill et

al 2011). It provides an upper-bound estimate of water use for irrigation, and was used to represent all irrigation water uses. Sampling results for total metals were used to evaluate these exposures.

3. **Exposures to irrigated soils and floodplain sediments.** Soil benchmarks that are protective of livestock were used as comparison values for the soil concentrations that were estimated from use of irrigation water and for sediment, based on the following references: *Soil criteria to protect terrestrial wildlife and open-range livestock from metal toxicity at mining sites* (Ford and Beyer 2014) and *National Range and Pasture Handbook* (NCRS 2003). Screening levels for soil for livestock are from Ford and Beyer 2014 and are available only for arsenic, cadmium, copper, lead, mercury, and zinc.
4. **Consumption of Homegrown Foods.** Use of water (total metals concentrations) to irrigate homegrown foods (i.e., meat, crops) was evaluated; this analysis was conducted using the estimated uptake of COPCs. These estimates were compared to human health based screening levels for ingestion of beef, sheep, and homegrown produce (ORNL 2018) to determine a potential risk or hazard associated with the exposure.
5. **Direct contact with Irrigated Soils**. Human health risks from direct soil contact, based on residential and occupation exposures, were also evaluated for irrigated soils using EPA RSLs.

Inputs to the exposure assessment for plants, cattle, and sheep are presented in Tables 11, 12, and 13, respectively. Soil and food ingestion rates were those used in Ford and Beyer 2014. Food ingestion rates for sheep and cattle were presented as dry weight values, and were converted to wet weight using a weighted average dry-to-wet weight conversion value of 0.888 from Baes et al. 1984. Water ingestion rates were selected from NRCS 2003, and represent the maximum values to account for variation in water needs due to temperature fluctuations and activity over the course of a year in an arid climate. Water quality criteria for chloride, total nitrate, and sulfate were also taken from NRCS 2003. Uptake factors for bioaccumulation of COPCs are from ORNL 2018.

4.4 Agriculture Risk Characterization

As shown in Table 10, soil concentrations at 1 year (i.e., 1 year of irrigation) are not above residential RSLs or occupational RSLs. At 10 years, all are below the residential RSLs with the exception of arsenic based on carcinogenic effects. The RSL for arsenic based on the carcinogenic risk of 1E-6 is 0.68 mg/kg for a residential exposure scenario, and the estimated soil concentration at 10 years is 0.847 mg/kg. At 100 years, the arsenic concentration is calculated to be 8.47 mg/kg and at 500 years is 42.3 mg/kg. No other exceedances were noted. These estimates do not include existing background concentrations nor do they include any forces that would decrease the metal content of the soil. At no point did the calculated soil concentrations exceed Outdoor Worker RSLs, which are based on a soil ingestion rate of 100 mg/kg. These results indicate that there is little hazard from direct exposure to soils irrigated with SJR water at this time, but there is the potential for soil concentrations to become unacceptable for arsenic after 10 years of irrigation when they would exceed acceptable levels for residential exposure

Table 10 also shows a screening of water concentrations to water concentrations protective of livestock. Barium at 20 mg/L total metals exceeds the livestock screening value of less than 10 mg/L. Cadmium is close to exceeding the screening value (0.03 mg/L) at the maximum concentration of 0.025 mg/L.

Table 11 contains the estimates of plant uptake of metals from soil irrigated with SJR water. Screening levels based on toxicity to plants from EPA Ecological Soil Screening Levels (SSLs) were used to evaluate the potential for irrigated soil to adversely affect plant health. In the absence of EPA Ecological SSLs, Toxicity Benchmarks for Ecological Receptors from Efroymson et al 1997 were used. Based on those screening values, only aluminum appears to be of concern, with a ratio of 9.5 for soil to screening level concentration. This indicates that aluminum could accumulate in soils even after one year to concentrations that are adverse to plant growth or yield. The screening benchmark level is based on only one study, and the authors note that the limited information does not allow for a high degree of confidence in this benchmark (Efroymson et al 1997). In addition, the Ecological SSLs note that aluminum is only toxic to plants when soil pH is below 5.5, which is not expected in southeastern Utah.

Table 12 presents the tissue concentration of COPCs in edible meat from cattle that have been exposed through consumption of irrigated crops and SJR water, and incidental ingestion of agricultural soils irrigated with SJR water. The table also contains the soil screening values for assessing potential health effects to cattle. Given that the soil concentrations estimated at 1 year are orders of magnitude below the soil screening values, adverse health effects to cattle are not expected via this exposure pathway. Water concentrations were also below screening levels and adverse health impacts to cattle are not expected.

Table 13 presents the same analysis for sheep. This analysis assumed that sheep uptake factors were the same as those for cattle because no bioaccumulation factors specific to sheep were identified, however lower ingestion rates for soil and water were assumed (Ford and Beyer 2014). No exceedances of soil or water screening values for sheep were identified, indicating that there is little potential for adverse health impacts to sheep.

As shown in Table 14, human ingestion of homegrown produce (using the concentrations in alfalfa as a proxy value for all homegrown produce), showed that only arsenic exceeded the produce ingestion screening value, based on carcinogenic effects. The estimated risk was 30E-6, which is within the risk range of 1E-6 to 1E-4. Given that the soil screening level for arsenic at 1 year did not exceed the residential RSL, this may be an overestimate of arsenic exposure and risk. All other estimated plant concentrations were below the screening value for produce ingestion and indicate little potential for hazard to humans. It should be noted, however, that this analysis estimates the incremental contribution of SJR water to total exposures and excludes any contribution from background concentrations to human exposure. Therefore, the incremental contribution of SJR water to human intakes does not indicate significant risk through this pathway.

Screening values for ingestion of produce are based on ingestion rates of 125.7 g/day of vegetables and 176.8 g/day of fruit by adults, and 41.7 g/day of vegetables and 68.1 g/day of fruit by a child. Different types of crops will uptake metals at different rates, so it is possible that using alfalfa as a surrogate is an overestimate of potential exposures through homegrown produce.

Table 15 presents the comparison of estimated beef concentration to screening values for beef ingestion. The tissue concentration estimates for cattle were higher than those for sheep and were used as bounding estimates of potential health hazards from ingestion of homegrown meats. Thallium was associated with a hazard quotient of 1.92, which is above the acceptable level of 1.0. Arsenic was associated with a risk of 1.25E-5, which is within the risk range of 1E-6 to 1E-4, but does exceed 1E-6. All other COPCs were below beef ingestion screening values. The beef ingestion screening values are based on a beef ingestion of 178 g/day by an adult (about 6 ounces) and 40.1 g/day (about 2 ounces) by a child, 350 days per year.

5 UNCERTAINTIES

The human health and agricultural risk assessments were based on the maximum detected concentrations of each COPC in surface water and sediment. This was a necessary assumption to address the uncertainty in concentrations as water levels vary in the SJR and are influenced by high flow or sediment disturbance. This assumption is associated with uncertainty that may over- or under-estimate risks. Background concentrations of metals in surface water, sediment, and soil were not considered in this assessment.

There is also uncertainty in the estimate of soil concentrations from the use of SJR water for irrigation. Deeper tillage may act to decrease concentrations, as deposited metals would be dispersed through a larger soil column. However, the estimates provided do not account for existing background levels of metals in soil, and therefore represent incremental amounts rather than an overall estimate of soil concentrations. Further, deeper tillage may make the metals more available to root systems. Conversely, decreases in metals through runoff, plant uptake, addition of soil amendments, or other means were not factored into the estimates.

The benchmark values used to assess potential adverse impacts to plants and uptake factors used to estimate uptake of metals to crops are not necessarily specific to alfalfa, introducing an uncertainty. Similarly, uptake factors for beef for each metal were used to assess metals uptake by sheep in the absence of accumulation factors specific to sheep. This may over- or underestimate concentrations of metals in edible tissues of sheep.

Benchmarks for livestock are health-based values and exposure parameters used to assess exposures are based on generally accepted values for sheep and cattle. However, these may not bound exposure parameters for cattle or sheep in southeastern Utah due to different ranching practices or temperature and climate conditions.

Ingestion rates for human consumption of homegrown produce and meat are also associated with uncertainty. Intake rates based on the majority of food being homegrown were used, and consumption may be less than this if other sources of food items are more commonly used.

Conversely, if all food consumed is homegrown, then these intake rates may not fully capture exposures and may lead to an underestimate of risk.

6 RISK SUMMARY

Based on the evaluation of risks associated with direct human exposure to SJR water and sediment, agricultural exposure pathways, and potential accumulation of metals in soil, there are no immediate risks to human health or agricultural receptors. However, there are some exceedances of risk- based screening levels, discussed below.

6.1 Human Health Risk Assessment

Dissolved concentrations of iron and manganese in water were above agricultural screening levels from UDEQ 2016, indicating that use of SJR water for irrigation has the potential to decrease the health or yield of some types of crops. In addition, the dissolved concentration of lead measured in the SJR slightly exceeded Utah's domestic water quality standard which could result in adverse human health impacts such as elevated blood lead levels in children. However, this exceedance was in only one sample and may not be indicative of long-term exposure concentrations.

The evaluation of total metal concentration in surface water showed that eight metals are potential hazards when compared to EPA RSLs (arsenic, barium, beryllium, cadmium cobalt, lead, thallium, and vanadium), six exceeded chronic EMEGs for children (antimony, arsenic, barium, beryllium, cadmium, and nickel) with four also exceeding chronic adult EMEGs (arsenic, barium, beryllium, and cadmium), one exceeded acute EMEGs for children (copper), and eight exceeded Utah's drinking water maximum contaminant levels or action levels (antimony, arsenic, barium, beryllium, cadmium, chromium, lead, and thallium. These exceedances are based on total metal concentrations in surface water and therefore may not be representative of at-the tap measurements from filtered or treated water. In addition, it is possible if not likely that domestic water supplies are from groundwater rather than directly from the river. Nonetheless, these exceedances indicate that domestic use of SJR water could result in adverse health effects to children and adults.

6.2 Agricultural Risk Assessment

Aluminum that may accumulate in irrigated soil was estimated to exceed benchmark levels for plant health, although EPA Ecological SSLs note that toxicity from aluminum is possible only if soil pH is less than 5.5. This evaluation was based on assumed water usage, a moderate depth of tillage, and the assumption that all metals were retained in the soil. This did not account for background concentrations, and therefore could be an underestimate of potential risk, but the intent of the SLRA was to focus on incremental risks. However, as indicated by the concentration of aluminum and by the exceedances of iron and manganese water quality values for long-term irrigation, this exposure pathway should be monitored.

Thallium in beef was associated with a hazard quotient above 1.0. This hazard applies to human ingestion of beef, rather than effects to cattle. This estimate is based on (1) direct ingestion of SJR water by cattle; (2) incidental ingestion by cattle of soil irrigated with SJR water; and (3) ingestion of plants and pasture grass irrigated by SJR water, using the total metal concentrations measured in water. This may result in an overestimate of tissue concentration, as the inputs may overestimate exposure of cattle due both to concentration and bioaccumulation potential. However, the estimates do not include the contribution of background concentrations.

7 RECOMMENDATIONS

Further monitoring of GKM-related COPCs is recommended. Aluminum, thallium, cadmium, lead, iron, manganese and arsenic should be measured in total and dissolved water samples in particular. In addition, the MCL exceedances of antimony, barium beryllium, and chromium indicate that monitoring of these constituents should be continued even if risk-based screening levels were not exceeded.

It may also be helpful to establish soil background concentrations for the land surrounding the SJR that is used agriculturally. Establishing background concentrations would help estimate total risks from agricultural products grown in this region, and can help protect the health of crops and livestock.

It is also recommended that assumptions of the screening level risk assessment be refined if there are site-specific considerations that require a more conservative set of inputs. The screening level risk assessment was purposely conservative in assessing exposure pathways that are likely to be complete. However, there could be other uses of the water in this agricultural area, other crops of concern, and local background values for metals in soil that result in more localized concerns.

No action is needed at this time to protect human health, livestock, or crops but any unusual health concerns should be reported by farmers in the area. In addition, any use of water or exposures to soil and sediment that are not captured by this assessment should be evaluated. This report has addressed typical pathways that usually result in an upper bound estimate of exposure, but if other pathways specific to this region are complete and of concern (such as a particular crop or atypical use of water), they should be added to the assessment.

8 REFERENCES

Agency for Toxic Substance and Disease Control (ATSDR) 2017. Comparison Values for Water. February 2017.

Baes CF, R.D. Sharp, AL. Sjoreen, R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Oak Ridge National Laboratory, ORNL-5786. September.

California EPA. 2009. Lead and Lead Compounds. Office of Environmental Health Hazard Assessment (OEHHA). OEHHA 2009 values, updated in 2011. Available at https://oehha.ca.gov/chemicals/lead-and-lead-compounds.

Efroymson RA, ME Will, GW Suter III, AC Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Prepared for the US Department of Energy, ES/ER/TM-85/R3.

Ford, KL and WN Beyer. 2014. Soil criteria to protect terrestrial wildlife and open-range livestock from metal toxicity at mining sites. Environmental Monitoring and Assessment (2014) 186:1899–1905.

Hill RW, Barker J.B., and Lewis CS. 2011. Crop and Wetland Consumptive Use and Open Water Surface Evaporation for Utah. Utah Agricultural Experimental Station Research Report #213. Utah State University. August 16, 2011.

National Academy of Science (NAS). 1972. Water Quality Criteria, 1972. A Report of the Committee on Water Quality Criteria. Washington, D.C.: Environmental Studies Board, National Academy of Science and National Academy of Engineering.

National Resource Conservation Service (NRCS). 2003. National range and pasture handbook. U.S. Department of Agriculture. Available at https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1043055.pdf

Oak Ridge National Laboratory (ORNL). 2018. Risk Assessment Information System (RAIS). RAIS Contaminated Media Risk Calculator. Available at https://rais.ornl.gov/

Raisbeck MF, SL Riker, CM Tate, R Jackson, MA Smith, KJ Reddy, and JR Zygmont. 2007. *Water Quality for Wyoming Livestock and Wildlife: A Review of the Literature Pertaining to Health Effects of Inorganic Contaminants*. University of Wyoming Department of Veterinary Sciences, University of Wyoming Department of Renewable Resource, Wyoming Department of Fish and Game, and Wyoming Department of Environmental Quality.

Raisbeck MF, B Wise, JR Zygmont, MA Smith, and CM Tate. 2011. *Water Quality for Wyoming Livestock and Wildlife: Final Report*. University of Wyoming Department of Veterinary Sciences, Wyoming Department of Environmental Quality, University of Wyoming Department of Renewable Resource, Wyoming Department of Fish and Game.

Tetra Tech 2017. Nature and Extent of San Juan River Data for Gold King Mine Risk Assessments. Submitted to UDEQ October 2, 2017.

Tetra Tech 2018. Screening Level Ecological Risk Assessment, San Juan River and Lake Powell Gold King Mine Incident, Prepared for Utah Department of Environmental Quality, Division of Water Quality. Draft, January 31, 2018.

UDEQ 2016. Utah's Long-term Monitoring and Assessment Plan for the San Juan River and Lake Powell, Utah. March 21, 2016.

USDA. 2017. Soils: Mivida Utah's State Soil. Natural Resource Conservation Service. Available at https://www.nrcs.usda.gov/wps/portal/nrcs/main/ut/soils/

USEPA. 1986. *Methods for Assessing Exposure to Chemical Substances, Volume 8: Methods for Assessing Environmental Pathways of Food Contamination*. Perwak, J., Ong, J.H., R. Whelan. EPA 540/5-85-008. U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC.

USEPA. 1989. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A).* Interim Final. EPA/540-1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 1991. *Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remedial Goals).* Interim. EPA/540/R-92/003. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 2003-2007 Ecological Soil Screening Levels for Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Nickel, Selenium, Silver, Vanadium, and Zinc. Office of Solid Waste and Emergency Response. Various directives numbers.

USEPA. 2004. 2004 Guidelines for Water Reuse. EPA/625/R-04/108. Office of Wastewater Management, U.S. Agency for International Development.

USEPA. 2007. Framework for Metals Risk Assessment. EPA/120/R-07/001. March. Office of the Science Advisor Risk Assessment Forum U.S. Environmental Protection Agency Washington, DC.

USEPA. 2016. Action Memorandum: Documentation of an Emergency Removal Action at the Gold King Mine Release Site, San Juan County, Colorado, initiated pursuant to the On-Scene Coordinator's delegated authority under CERCLA Section 104 and a Request for Approval and Funding to Continue the Emergency Removal Action including Exemptions from the 12-Month and $2 Million Statutory Limits on Removal Actions. USEPA, Washington, DC.

USEPA. 2017. *Regional Screening Levels (RSLs), User's Guide (June 2017).* https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-June-2017.

USEPA. 2018. Integrated Risk Information System (IRIS). Available at https://www.epa.gov/iris.

FIGURES

Figure 1. Sampling locations

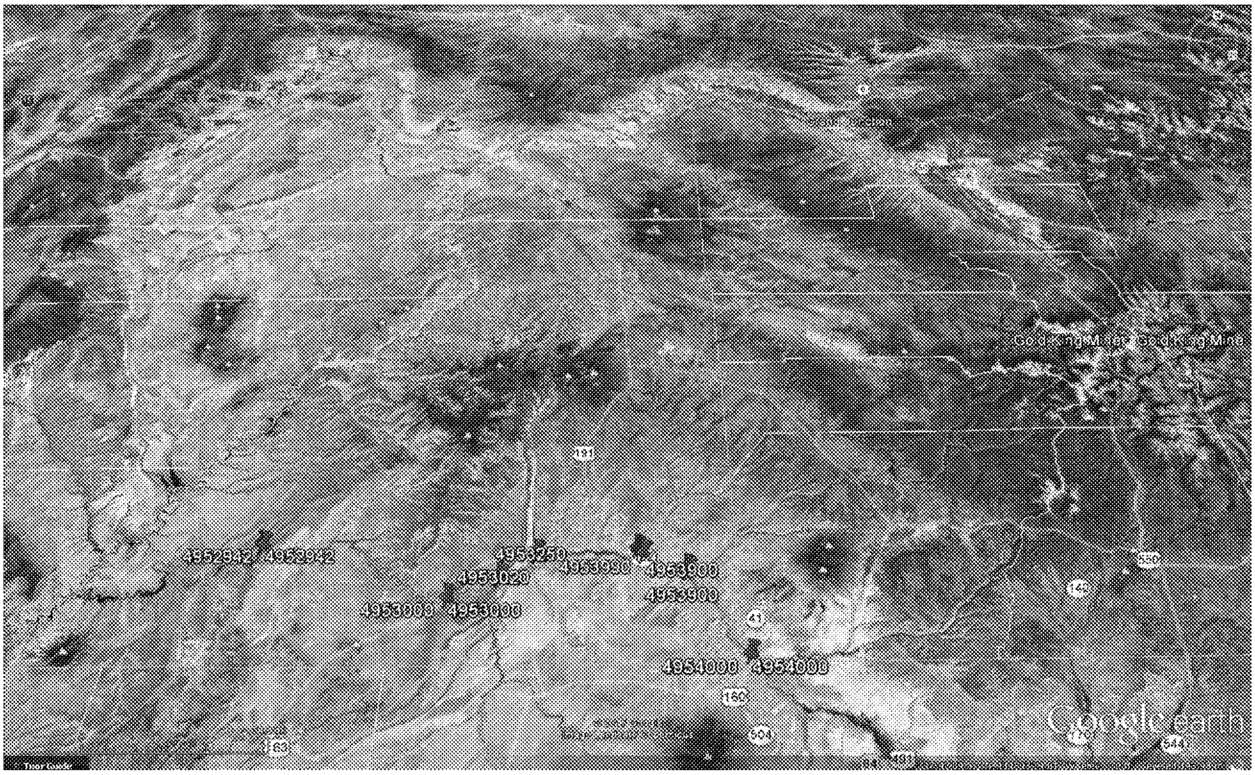
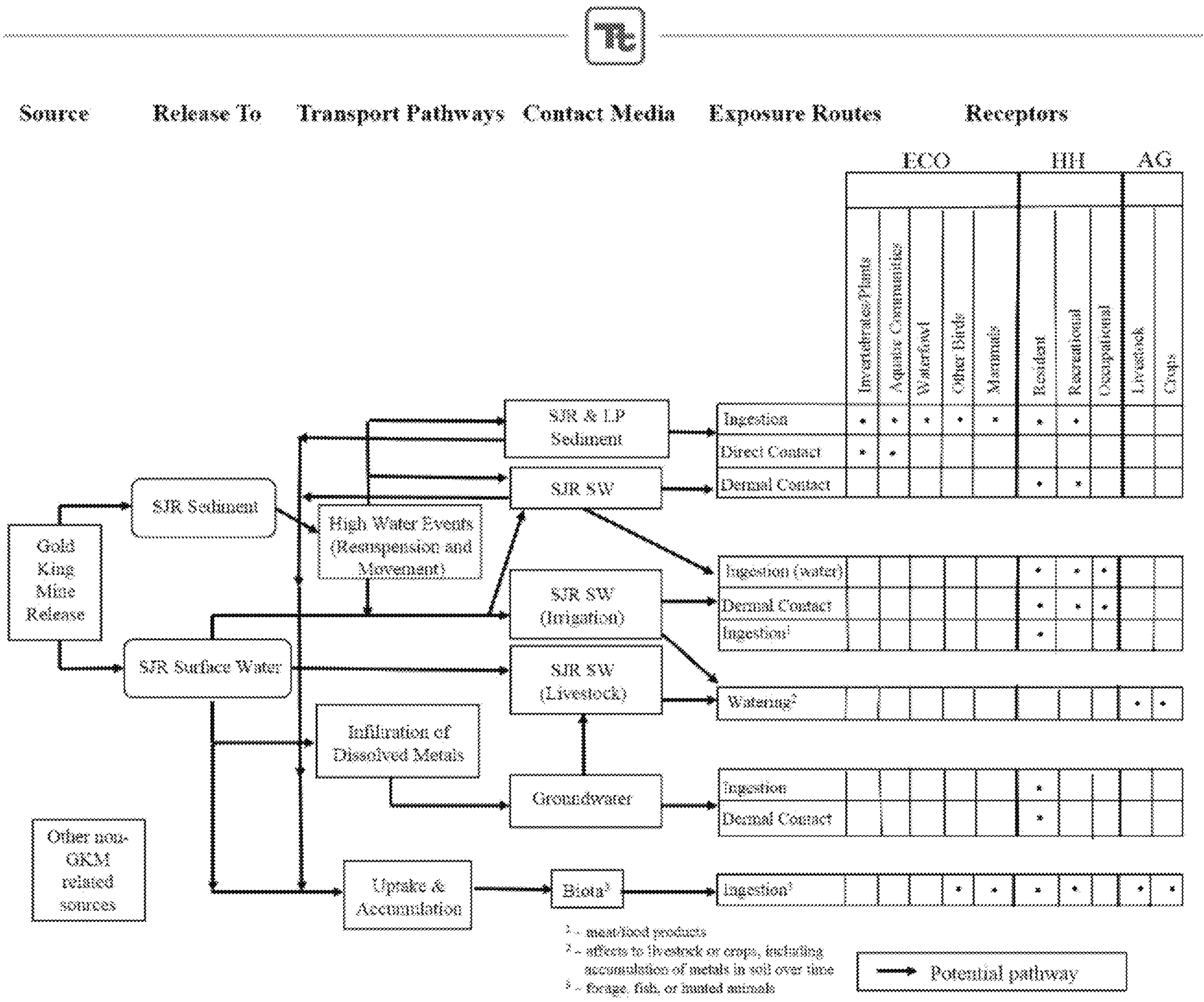


Figure 2. Conceptual Site Model for the San Juan River and Lake Powell related to the Gold King Mine Incident



ED_004888_00026032-00039

TABLES

Table 1. Estimated mass of metals delivered to the Animas River from the Gold King mine release (USEPA 2017).

Metal	Total (kg)	Dissolved (kg)	Collodial/Particulate (kg)
Aluminum	41,132	6,376	34,755
Antimony	14.2	0.173	14.0
Arsenic	358.4	2.9	355.4
Barium	417.6	2.2	415.4
Beryllium	6.0	2.4	3.6
Cadmium	7.7	7.0	0.7
Calcium	30,484	30,345	139
Chromium	30.6	0.38	30.2
Cobalt	17.7	14	3.7
Copper	1,615	731	884
Iron	433,086	3,750	429,335
Lead	7,658	11.2	7,647
Magnesium	15,891	2,490	13,401
Manganese	3,599	2,581	1,018
Mercury	0.8	0.0001	0.8
Molybdenum	86.8	0.4	86.4
Nickel	12.5	6	6.2
Potassium	11,854	426	11,428
Selenium	11.2	0.4	10.8
Silver	47.4	0.2	47.3
Sodium	1427.4	290	1,137.1
Thallium	5.6	0.2	5.4
Vanadium	237.8	0.8	237.0
Zinc	2,059	1,904	155
Total Metals	550,060	48,942	501,118
Major Cations	59,656	33,551	26,106
Total Minus Cations	490,404	15,391	475,012
Sulfate	18,170	NA	NA
Chloride	13,63	NA	NA
Fluoride	114.0	NA	NA
Nitrate as N	0.28	NA	NA

Table 2. Summary of Maximum Surface Water concentrations at each sampling point on the main stem SJR, as well as the maximum measured in all sampling locations representing the SJR in UT. (Note: The bold font below indicates the maximum concentration for the seven SJR stations.)

Analyte	**Units**	**4954000**	**4953990**	**4953880**	**4953250**	**4953000**	**4952942**	**4952940**	**San Juan River (UT) (maximum concentration)**
		SJR @ US 160 Xing in CO	SJR @ Town of Montezuma	SJR @ McElmo Wash	SJR @ Sand Island	SJR @Mexican Hat US163 Xing	SJR @ Clay Hills	SJR Above Lake Powell	
Aluminum total	mg/L	**248**	223	20.4	200	163	154	3.79	248
Aluminum dissolved	µg/L	**20700**	1400	69.57	684	1790	1100	NA	20700
Antimony total	µg/L	3	3	3	3	**6**	1	NA	6
Antimony dissolved	µg/L	3	**3.458**	3	3	3	1.01	NA	3.458
Arsenic total	µg/L	35.9	40.1	10.1	32.1	**45**	36.6	39	45
Arsenic dissolved	µg/L	**5.55**	1.58	1.74	2.03	2.33	2.89	NA	5.55
Barium total	µg/L	6530	6480	2500	4180	**20000**	7600	6460	20000
Barium dissolved	µg/L	**451**	314	224	294	445	411	NA	451
Beryllium total	µg/L	**53.3**	22	1.3	20.4	15.2	16.6	NA	53.3
Beryllium dissolved	µg/L	**1.58**	1	1	1	1	0.067	NA	1.58
Cadmium total	µg/L	**24.9**	10.3	0.95	4.5	6.26	10.7	21.5	24.9
Cadmium dissolved	µg/L	0.261	**0.303**	0.1	0.1	0.1	NA	NA	0.303
Calcium total	mg/L	3230	3810	277	391	1070	**4230**	3360	4230
Calcium dissolved	mg/L	74.1	95	**272**	85.6	87.9	239	NA	272
Chloride total	mg/L	16.2	20.9	**55.6**	21.2	24.7	35	NA	55.6
Chromium total	µg/L	**123**	111	12.9	95	104	61.6	NA	123
Chromium dissolved	µg/L	**12**	2	2	5.37	2	NA	NA	12
Cobalt total	µg/L	**254**	150	30	109	84.5	99.8	250	254
Cobalt dissolved	µg/L	**30**	30	30	30	30	1.08	NA	30

Table 2. Summary of Maximum Surface Water Dissolved and Total Metals Concentrations (Continued).

Analyte	**Units**	**4954000** SJR @ US 160 Xing in CO	**4953990** SJR @ Town of Montezuma	**4953880** SJR @ McElmo Wash	**4953250** SJR @ Sand Island	**4953000** SJR @Mexican Hat US163 Xing	**4952942** SJR @ Clay Hills	**4952940** SJR Above Lake Powell	**San Juan River (UT) (maximum concentration)**
Copper total	µg/L	**333**	245	23.4	266	266	131	74.9	333
Copper dissolved	µg/L	**27.7**	4.38	3.78	3.89	8.56	5.26	NA	27.7
Iron total	mg/L	**181**	173	26.2	171	110	99.6	70.6	181
Iron dissolved	mg/L	**16.7**	0.668	0.0775	0.328	0.787	0.774	NA	16.7
Lead total	µg/L	**369**	308	27.4	238	200	175	6.3	369
Lead dissolved	µg/L	**15.7**	0.49	0.219	0.582	0.717	0.924	NA	15.7
Magnesium total	mg/L	401	**478**	188	89.3	188	443	391	478
Magnesium dissolved	mg/L	13.7	21.28	**181**	23.3	22.9	35.5	NA	181
Manganese total	mg/L	30.3	23.9	1.53	6.8	7.39	22.1	**39.5**	39.5
Manganese dissolved	mg/L	**0.413**	0.0265	0.0691	0.0094	0.0197	0.0161	NA	0.413
Mercury total	µg/L	1.62	1.25	0.2	0.597	0.72	**1.77**	NA	1.77
Mercury dissolved	µg/L	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	NA	NA	0.2
Molybdenum total	µg/L	3.65	3.79	5.58	5.31	5.87	**15.9**	2.44	15.9
Molybdenum dissolved	µg/L	3.65	2.84	5.51	5.31	**5.87**	4.27	NA	5.87
Nickel total	µg/L	**375**	231	21.8	143	184	110	201	375
Nickel dissolved	µg/L	**12.7**	5	5	5	5	1.51	NA	12.7
Potassium total	mg/L	**48.5**	36.7	12.2	32.3	36.2	33	32.7	48.5
Potassium dissolved	mg/L	**7.89**	6.46	6.78	5.25	5.14	7.19	NA	7.89

Table 2. Summary of Maximum Surface Water Dissolved and Total Metals Concentrations (Continued).

Analyte	**Units**	**4954000** SJR @ US 160 Xing in CO	**4953990** SJR @ Town of Montezuma	**4953880** SJR @ McElmo Wash	**4953250** SJR @ Sand Island	**4953000** SJR @Mexican Hat US163 Xing	**4952942** SJR @ Clay Hills	**4952940** SJR Above Lake Powell	**San Juan River (UT) (maximum concentration)**
Selenium total	µg/L	16.5	**33**	2.5	22.2	25.9	13.9	NA	33
Selenium dissolved	µg/L	1.577	1.622	2.548	1.465	**2.97**	1.74	NA	2.97
Silver total	µg/L	**6.71**	1.91	0.5	1.68	1.51	0.923	NA	6.71
Silver dissolved	µg/L	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	0.08	NA	0.5
Sodium total	mg/L	**377**	85.6	228	70.7	82.9	108	99.6	377
Sodium dissolved	mg/L	89.6	72.7	**225**	70.7	71.7	67.5	NA	225
Strontium total	mg/L	1.22	1.4	**5.73**	1.44	1.76	1.32	NA	5.73
Strontium dissolved	mg/L	0.816	0.957	**4.57**	0.98	1.03	1.07	NA	4.57
Thallium total	µg/L	**2.59**	2.24	0.43	2.33	1.56	1.35	NA	2.59
Thallium dissolved	µg/L	0.18	0.1	0.1	0.16	**0.28**	0.05	NA	0.28
Vanadium total	µg/L	**178**	167	38.5	162	141	117	NA	178
Vanadium dissolved	µg/L	**30**	**30**	**30**	**30**	**30**	12.6	NA	30
Zinc total	µg/L	**1250**	1010	77.7	960	843	477	1040	1250
Zinc dissolved	µg/L	72.8	**191**	13.4	20.4	30.1	20.6	NA	191

Table 3. Summary of Maximum Sediment Concentrations at each sampling point on the main stem SJR, as well as the maximum measured in all sampling locations representing the SJR in UT. (Note: The bold font below indicates the maximum concentration for the seven SJR stations.)

Analyte	**Units**	**4954000**	**4953990**	**4953880**	**4953250**	**4953000**	**4952942**	**4952940**	**San Juan River (UT) (maximum concentration)**
		SJR @ US 160 Xing in CO	SJR @ Town of Montezuma	SJR @ McElmo Wash	SJR @ Sand Island	SJR @Mexican Hat US163 Xing	SJR @ Clay Hills	SJR Above Lake Powell	
Aluminum total	mg/kg	4179	**6140**	NA	4250	3728	2720	NA	6140
Antimony total	mg/kg	4.47	4.48	NA	4.18	4.42	4.63	NA	4.63
Arsenic total	mg/kg	1.9	1.74	NA	**2**	1.6	1.1	NA	2
Barium total	mg/kg	135.9	161	NA	**191.1**	137.5	163	NA	191.1
Beryllium total	mg/kg	0.289	**0.291**	NA	0.226	0.19	0.162	NA	0.291
Cadmium total	mg/kg	**0.111**	0.1	NA	0.0796	0.0897	0.0648	NA	0.111
Calcium total	mg/kg	7780	8470	NA	4610	6620	**9870**	NA	9870
Chromium total	mg/kg	**5.13**	5.02	NA	2.32	3.33	3.09	NA	5.13
Cobalt total	mg/kg	**2.53**	1.76	NA	2.12	1.7	1.41	NA	2.53
Copper total	mg/kg	**3.45**	3.43	NA	2.53	2.33	1.85	NA	3.45
Iron total	mg/kg	5628	5530	NA	**6340**	4250	3760	NA	6340
Lead total	mg/kg	**4.48**	3.9	NA	4.24	4.3	2.99	NA	4.48
Magnesium total	mg/kg	**2000**	1900	NA	1740	1350	1790	NA	2000
Manganese total	mg/kg	182	156	NA	**198**	132	138	NA	198
Mercury total	mg/kg	0.00182	**0.00569**	NA	0.00284	0.0019	0.00205	NA	0.00569
Molybdenum total	mg/kg	0.422	0.355	NA	NA	**0.43**	NA	NA	0.43
Nickel total	mg/kg	**3.6**	2.8	NA	2.15	2.23	2.52	NA	3.6
Potassium total	mg/kg	1055	**1665**	NA	535	788.6	787	NA	1665
Selenium total	mg/kg	2.1	**3.8**	NA	2.7	2.4	2.4	NA	3.8

Table 3. Summary of Maximum Sediment Concentrations (Continued).

Analyte	Units	4954000 SJR @ US 160 Xing in CO	4953990 SJR @ Town of Montezuma	4953880 SJR @ McElmo Wash	4953250 SJR @ Sand Island	4953000 SJR @Mexican Hat US163 Xing	4952942 SJR @ Clay Hills	4952940 SJR Above Lake Powell	San Juan River (UT) (maximum concentration)
Silver total	mg/kg	0.0302	0.0286	NA	0.0243	**0.0679**	0.0458	NA	0.0679
Sodium total	mg/kg	**190**	145	NA	126	177	113	NA	190
Strontium total	mg/kg	97.7	114.7	NA	99.4	74.2	**133.1**	NA	133.1
Thallium total	mg/kg	0.0502	**0.0677**	NA	0.0636	0.0507	0.0334	NA	0.0677
Vanadium total	mg/kg	10.5	**13.5**	NA	7.43	8	6.74	NA	13.5
Zinc total	mg/kg	16.9	18.5	NA	**18.9**	13.3	10.4	NA	18.9

Table 4. Toxicity Values for the Human Health Risk Assessment

Chemical	CAS No.	Cancer Toxicity Values			Noncancer Chronic Toxicity Values		EPA RSLs		
		Cancer Classification	Cancer Oral Slope Factor (mg/kg-day)$^{-1}$	Basis of Cancer Oral Slope Factor	Chronic RfD mg/kg-day	Basis of Chronic RfD	Tap Water (ug/L)	Residential Soil (mg/kg)	Occupational Soil (mg/kg)
Aluminum	7429-90-5	NA	NA	NA	1.00E+00	Provisional value; based on minimal neurotoxicity in the offspring of mice. Uncertainty factor = 100	20,000	7.70E+04	1100000
Antimony	7440-36-0	NA	NA	NA	4.00E-04	IRIS 2018. Animal Study, Target organ - longevity, blood glucose, cholesterol. Schroeder et al, 1970. Uncertainty factor = 1000	7.8	31	470
Arsenic (1)	7440-38-2	A (human carcinogen)	1.50E+00	IRIS 1995. Increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.	3.00E-04	IRIS 1991. Animal study - hyperpigmentation, keratosis and possible vascular complications. Tseng, 1997; Tseng et al., 1968. Uncertainty factor - 3	0.052 / 6	0.68 / 35	3 / 480
Barium	7440-39-3	Not likely to be carcinogenic to humans (Oral route)	NA	NA	2.00E-01	IRIS 2005. Animal Study - Nephropathy, 2-year drinking water study in mice. NTP, 1994. Uncertainty factor - 300	3800	1.50E+04	220000

Table 4. Toxicity Values for the Human Health Risk Assessment (Continued).

Chemical	CAS No.	Cancer Toxicity Values			Noncancer Chronic Toxicity Values		EPA RSLs		
		Cancer Classification	Cancer Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Basis of Cancer Oral Slope Factor	Chronic RfD mg/kg-day	Basis of Chronic RfD	Tap Water (ug/L)	Residential Soil (mg/kg)	Occupational Soil (mg/kg)
Boron	7440-42-8	Data are inadequate for an assessment of human carcinogenic potential (Oral route)	NA	NA	2.00E-01	IRIS 2004. Animal Study - Decreased fetal weight (developmental), rat dietary gestational exposure to boric acid. Price et al., 1996, Heindel et al., 1992. Uncertainty factor - 66	4000	1.60E+04	230000
Beryllium	7440-41-7	Carcinogenic potential cannot be determined (Oral route)	NA	NA	2.00E-03	IRIS 1998. Animal study - Small intestinal lesions, dog dietary study. Morgareidge et al., 1976. Uncertainty factor - 300	25	160	2300
Cadmium	7440-43-9	B1 (Probable human carcinogen)	NA	NA	5.00E-04 (water) 1.00E-3 (food)	IRIS 1989. Human study - Significant proteinuria, human studies involving chronic exposures. USEPA, 1985. Uncertainty factor - 10	9.2	71	980
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NA	NA	NA	1.50E+00	*Chromium assumed to be trivalent chromium; RfD is based on the no observed effects level, Uncertainty factor = 100	2.20E+04	1.20E+05	1800000
Cobalt	7440-48-4	NA	NA	NA	3.00E-04	Provisional value; based on decreased uptake of iodine to thyroid in humans. Uncertainty factor = 3000	6	23	350

Table 4. Toxicity Values for the Human Health Risk Assessment (Continued).

Chemical	CAS No.	Cancer Toxicity Values			Noncancer Chronic Toxicity Values		EPA RSLs		
		Cancer Classification	Cancer Oral Slope Factor (mg/kg-day)$^{-1}$	Basis of Cancer Oral Slope Factor	Chronic RfD mg/kg-day	Basis of Chronic RfD	Tap Water (ug/L)	Residential Soil (mg/kg)	Occupational Soil (mg/kg)
Copper	7440-50-8	D (Not classifiable as to human carcinogenicity)	NA	NA	NA	NA	800	3100	47000
Iron	7439-89-6	NA	NA	NA	7.00E-01	PPTRV value; EPA 2006. Based on LOAEL for adverse GI effects. Uncertainty Factor = 1.5.	14000	5.50E+04	820000
Lead	7439-92-1	B2 (Probable human carcinogen)	8.50E-03	From California EPA 2009 (updated 2011). Used to assess risks from fish, plant, and beef ingestion only	NA	NA	15	400	800
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	D (Not classifiable as to human carcinogenicity)	NA	NA	1.40E-01	IRIS 1995. Human studies - CNS effects, human chronic ingestion data. NRC, 1989; Freeland-Graves et al., 1987; WHO, 1973. Uncertainty factor - 1	430	1800	26000
Mercury	7439-97-6	D (Not classifiable as to human carcinogenicity)	NA	NA	NA	NA	5.7	11	46
Molybdenum	7439-98-7	NA	NA	NA	5.00E-03	IRIS 1992. Human study - Increased uric acid levels. Human 6-year to lifetime dietary exposure study. Koval'skiy et al., 1961. Uncertainty factor - 30	100	390	5800

Table 4. Toxicity Values for the Human Health Risk Assessment (Continued).

Chemical	CAS No.	Cancer Toxicity Values			Noncancer Chronic Toxicity Values		EPA RSLs		
		Cancer Classification	Cancer Oral Slope Factor (mg/kg-day)$^{-1}$	Basis of Cancer Oral Slope Factor	Chronic RfD mg/kg-day	Basis of Chronic RfD	Tap Water (ug/L)	Residential Soil (mg/kg)	Occupational Soil (mg/kg)
Nickel	7440-02-0	NA	NA	NA	2.00E-02	IRIS 1991. Animal study - decreased body and organ weights. Rat chronic oral study. Ambrose et al., 1976. Uncertainty factor - 300	390	1.50E+03	22000
Potassium	7440-09-7	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	D (Not classifiable as to human carcinogenicity)	NA	NA	5.00E-03	IRIS 1991. Human epidemiological study. Clinical selenosis. Yang et al., 1989. Uncertainty factor - 3	100	390	580
Silver	7440-22-4	D (Not classifiable as to human carcinogenicity)	NA	NA	5.00E-03	IRIS 1991. 2- to 9-year human i.v. study. Argyria. Gaul and Staud, 1935. Uncertainty factor - 3	94	390	580
Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	NA	NA	NA	6.00E-01	IRIS 1992. Animal study - 20-day, 9-week, and 3-year oral studies in young and adult rats. Rachitic bone. Storey, 1961; Marie et al., 1985; Skoryna, 1981. Uncertainty factor - 300	12	4.70E+04	700000
Thallium	7440-28-0	Inadequate information to assess carcinogenic potential	NA	NA	1.00E-05	PPTRV value; EPA 2006. Based on animal studies. NOAEL for adverse observations of coat and eyes in experimental animals. Uncertainty Factor = 3000	0.2	0.78	12
Vanadium	7440-62-2	NA	NA	NA	5.00E-03	Based on Vanadium Pentoxide, adjusted for molecular weight (EPA 2017). RfD for Vanadium Pentoxide is dermal effects in experimental animals and has an uncertainty factor of 100.	86	390	5800

Table 4. Toxicity Values for the Human Health Risk Assessment (Continued).

Chemical	CAS No.	Cancer Toxicity Values			Noncancer Chronic Toxicity Values		EPA RSLs		
		Cancer Classification	Cancer Oral Slope Factor (mg/kg-day)$^{-1}$	Basis of Cancer Oral Slope Factor	Chronic RfD mg/kg-day	Basis of Chronic RfD	Tap Water (ug/L)	Residential Soil (mg/kg)	Occupational Soil (mg/kg)
Zinc	7440-66-6	Inadequate information to assess carcinogenic potential	NA	NA	3.00E-01	IRIS 2005. Human studies - Decreases in erythrocyte Cu, Zn-superoxide dismutase (ESOD) activity in healthy male and female volunteers. Yadrick et al., 1989, Fischer et al., 1984, Davis et al., 2000, Milne et al., 2001. Uncertainty factor - 3	6000	2.30E+04	350000

Cns/Pns - Central nervous system/Peripheral nervous system

Cv/Bld - Cardiovascular/Blood system

Imm - Immune system

(1) RSL E11Values for arsenic represent the RSL based on carcinogenic effects / noncarcinogenic effects

Table 5. Toxicity-Based Screening Values for the Agricultural Risk Assessment

Chemical	CAS No.	Screening Levels							
		Water-Cattle and Sheep (mg/L)	Source	Soil - Plants	Source	Soil - Cattle	Source	Soil - Sheep	Source
Aluminum	7429-90-5	NA	NA	50	2	NA	NA	NA	NA
Antimony	7440-36-0	NA	NA	5	2	2.70E-01	1	2.70E-01	1
Arsenic (1)	7440-38-2	1	4	18	1	355	3	353	3
Barium	7440-39-3	NA	NA	500	2	2.00E+03	1	2.00E+03	1
Boron	7440-42-8	NA	NA	0.50	2				
Beryllium	7440-41-7	NA	NA	10	2	2.10E+01	1	2.10E+01	1
Cadmium	7440-43-9	NA	NA	32	1	20	3	12	3
Calcium	7440-70-2	500	4	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NA	NA	1	2	NA	NA	NA	NA
Cobalt	7440-48-4	NA	NA	13	1	2.30E+02	1	2.30E+02	1
Copper	7440-50-8	NA	NA	70	1	281	3	86	3
Iron	7439-89-6	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	NA	NA	120	1	1127	NA	203	NA
Magnesium	7439-95-4	250	4	NA	NA	4.00E+03	1	4.00E+03	1
Manganese	7439-96-5	NA	NA	220	1	NA	NA	NA	NA
Mercury	7439-97-6	NA	NA	0.30	2	22	3	38	3
Molybdenum	7439-98-7	NA	NA	2	2	NA	NA	NA	NA
Nickel	7440-02-0	NA	NA	38	1	1.30E+02	1	1.30E+02	1
Potassium	7440-09-7	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	0.52	1	6.30E-01	1	6.30E-01	1
Silver	7440-22-4	NA	NA	560	1	1.40E+01	1	1.40E+01	1
Sodium	7440-23-5	1000	4	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	7440-28-0	NA	NA	1	2	NA	NA	NA	NA
Vanadium	7440-62-2	NA	NA	2	2	NA	NA	NA	NA
Zinc	7440-66-6	NA	NA	160	1	1600	3	545	3
Chloride	16887-00-6	1500	4	NA	NA	NA	NA	NA	NA
Total Nitrate	18785-72-3	100	4	NA	NA	NA	NA	NA	NA
Sulfate	14797-65-0	500	4	NA	NA	NA	NA	NA	NA

NA = Not Available
Sources:
(1) Eco SSLs, USEPA
(2) Efroymson et al. 1007
(3) Ford and Beyer 2014
(4) NRCS 2003

Table 6a. Screening Values for Dissolved Metals Concentrations in Surface Water.

Analyte	CAS No.	Units	Utah Water Quality Standards (Numeric Criteria) (UAC R317-2-14) for San Juan River Uses [dissolved metals]				Utah Primary Drinking Water Standards (UAC R309-200-5) [total metals]		Agricultural Screening Values [dissolved metals]			SJR Max Value (Concentration Used for Screening)
			1C (domestic)	3B (warm water fish) [1-hour]	3B (warm water fish) [4-day]	4 (agriculture)	Maximum Contaminant Level	Action Level	Livestock Water	Long-Term Irrigation Waters	Short-Term Irrigation Waters	
Hardness	NA	mg/L	NA	NA	NA	NA	NA	NA	180	NA	NA	10000
Aluminum	7429-90-5	µg/L	NA	750	87	NA	NA	NA	5000	5000	20000	20700
Antimony	7440-36-0	µg/L	NA	NA	NA	NA	6	NA	NA	NA	NA	3.458
Arsenic	7440-38-2	µg/L	10	340	150	100	10	NA	200	100	2000	5.55
Barium	7440-39-3	µg/L	1000	NA	NA	NA	2000	NA	NA	NA	NA	451
Boron	7440-42-8	µg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	µg/L	<4	NA	NA	NA	4	NA	NA	NA	NA	1.58
Cadmium	7440-43-9	µg/L	10	2	0.25	10	5	NA	50	10	50	0.303
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	NA	NA	500	NA	NA	272
Chromium	7440-47-3	µg/L	50	16 (VI); 570 (III)	11 (VI); 74 (III)	100	100	NA	1000	100	1000	12
Cobalt	7440-48-4	µg/L	NA	NA	NA	NA	NA	NA	1000	50	5000	30
Copper	7440-50-8	µg/L	NA	13	9	200	NA	1300	500	200	5000	27.7
Iron	7439-89-6	µg/L	NA	1000	1000	NA	NA	NA	NA	5000	20000	16700
Lead	7439-92-1	µg/L	15	65	2.5	100	NA	15	100	5000	10000	15.7
Magnesium	7439-95-4	mg/L	NA	NA	NA	NA	NA	NA	250	NA	NA	181
Manganese	7439-96-5	µg/L	NA	NA	NA	NA	NA	NA	NA	200	10000	413
Mercury	7439-97-6	µg/L	2	NA	0.012	NA	2	NA	10	NA	NA	0.2
Molybdenum	7439-98-7	µg/L	NA	NA	NA	NA	NA	NA	NA	10	50	5.87
Nickel	7440-02-0	µg/L	NA	468	52	NA	NA	NA	NA	200	2000	12.7
Potassium	7440-22-4	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.89
Selenium	7782-49-2	µg/L	50	18.4	4.6	50	50	NA	50	20	20	2.97
Silver	7440-22-4	µg/L	50	1.6	NA	NA	NA	NA	NA	NA	NA	0.5
Sodium	7440-23-5	µg/L	NA	NA	NA	NA	NA	NA	1000000	NA	NA	225
Strontium	7440-24-6	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.57
Thallium	7440-28-0	µg/L	NA	NA	NA	NA	2	NA	NA	NA	NA	0.28
Vanadium	7440-62-2	µg/L	NA	NA	NA	NA	NA	NA	100	100	1000	30
Zinc	7440-66-6	µg/L	NA	120	120	NA	NA	NA	25000	2000	10000	191
TDS	NA	mg/L	NA	NA	NA	1200	NA	NA	NA	500000-1000000		NA
pH	NA	NA	NA	NA	6.5-9.0	6.5-9.0	NA	NA	NA	NA	NA	NA

Table 6b. Results of Screening of Dissolved Metals Concentrations in Surface Water.

Analyte	CAS No.	Units	Ratio of Max Value Compared to Historical Max Background Value	Ratios of SJR Max Value Compared to Regulatory Screening Levels						
				Utah Water Quality Standards (Numeric Criteria) (UAC R317-2-14) for San Juan River Uses [dissolved metals]				Agricultural Screening Values [dissolved metals]		
				1C (domestic)	3B (warm water fish) [1-hour]	3B (warm water fish) [4-day]	4 (agriculture)	Livestock Water	Long-Term Irrigation Waters	Short-Term Irrigation Waters
Hardness	NA	mg/L	27	NA	NA	NA	NA	56	NA	NA
Aluminum	7429-90-5	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	7440-36-0	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	µg/L	2.8	0.56	0.016	0.037	0.056	0.028	0.056	0.0028
Barium	7440-39-3	µg/L	4.5	0.45	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	µg/L	0.076	0.030	0.15	1.2	0.030	0.006	0.030	0.0061
Calcium	7440-70-2	mg/L	2.6	NA	NA	NA	NA	0.54	NA	NA
Chromium	7440-47-3	µg/L	1.2	0.24	0.75	1.1 (VI)	0.12	0.012	0.12	0.012
Cobalt	7440-48-4	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	µg/L	2.8	NA	2.1	3.1	0.14	0.055	0.14	0.0055
Iron	7439-89-6	µg/L	67	NA	17	17	NA	NA	3.3	0.84
Lead	7439-92-1	µg/L	0.79	1.05	0.24	6.3	0.16	0.16	0.0031	0.0016
Magnesium	7439-95-4	mg/L	4.1	NA	NA	NA	NA	0.72	NA	NA
Manganese	7439-96-5	µg/L	83	NA	NA	NA	NA	NA	2.1	0.041
Mercury	7439-97-6	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	7439-98-7	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	µg/L	0.51	NA	0.03	0.24	NA	NA	0.06	0.0064
Potassium	7440-22-4	mg/L	1.1	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	µg/L	0.99	0.059	0.16	0.65	0.059	0.059	0.15	0.15
Silver	7440-22-4	µg/L	0.10	0.010	0.31	NA	NA	NA	NA	NA
Sodium	7440-23-5	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	7440-28-0	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	µg/L	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	µg/L	13	NA	1.59	1.6	NA	0.0076	0.10	0.019
TDS	NA	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
pH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 7a. Screening Values for Total Metals Concentrations in Surface Water

Analyte	CAS No.	Units	Risk-Based Screening Concentrations for Water					Utah Primary Drinking Water Standards (UAC R309-200-5) [total metals]		Recreational Screening Values [total metals]	SJR Max Value (Concentration Used for Screening)
			EPA Tap Water RSL (noncarcinogenic)	EPA Tap Water RSL (carcinogenic)	ATSDR Chronic EMEG (child)	ATSDR chronic EMEG (adult)	ASTDR Acute EMEG	Maximum Contaminant Level	Action Level		
Hardness	NA	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	7429-90-5	μg/L	20,000	NA	7,000	26000	NA	NA	NA	620767	248
Antimony	7440-36-0	μg/L	7.8	NA	***2.8***	***10***	NA	6	NA	248	6
Arsenic	7440-38-2	μg/L	6	0.052	2.1	7.8	35 c/ 130 a	10	NA	186	45
Barium	7440-39-3	μg/L	3800	NA	1400	5200	NA	2000	NA	124159	20000
Boron	7440-42-8	μg/L	4000	NA	***1400***	***5200***	1400/5200	NA	NA	NA	NA
Beryllium	7440-41-7	μg/L	25	NA	14	52	NA	4	NA	1242	53.3
Cadmium	7440-43-9	μg/L	9.2	NA	0.7	2.6	NA	5	NA	62	24.9
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	4230
Chromium	7440-47-3	μg/L	NA	NA	NA	NA	NA	100	NA	410	123
Cobalt	7440-48-4	μg/L	6	NA	NA	NA	NA	NA	NA	7931	254
Copper	7440-50-8	μg/L	800	NA	NA	NA	70/260	NA	1300	6208	333
Iron	7439-89-6	μg/L	14000	NA	NA	NA	NA	NA	NA	851582	181
Lead	7439-92-1	μg/L	15	NA	NA	NA	NA	NA	15	910	369
Magnesium	7439-95-4	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	478
Manganese	7439-96-5	μg/L	430	NA	350	1300	NA	NA	NA	31040	39.5
Mercury	7439-97-6	μg/L	5.7	NA	NA	NA	NA	2	NA	1242	1.77
Molybdenum	7439-98-7	μg/L	100	NA	35	130	NA	NA	NA	3104	15.89
Nickel	7440-02-0	μg/L	390	NA	140	520	NA	NA	NA	17480	375
Potassium	7440-22-4	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	48.5
Selenium	7782-49-2	μg/L	100	NA	35	130	NA	50	NA	3104	33
Silver	7440-22-4	μg/L	94	NA	***35***	***130***	NA	NA	NA	3630	6.71
Sodium	7440-23-5	μg/L	NA	NA	NA	NA	NA	NA	NA	NA	377
Strontium	7440-24-6	mg/L	12	NA	NA	NA	NA	NA	NA	NA	5.73
Thallium	7440-28-0	μg/L	0.2	NA	NA	NA	NA	2	NA	25	2.59
Vanadium	7440-62-2	μg/L	86	NA	*70*	*260*	NA	NA	NA	6208	178
Zinc	7440-66-6	μg/L	6000	NA	2100	7800	NA	NA	NA	217786	1250

Table 7b. Results of Screening of Total Metals Concentrations in Surface Water.

Analyte	CAS No.	Ratios of SJR Max Value Compared to Risk-based Screening Levels							
		Risk and Hazards for Water					Utah Primary Drinking Water Standards (UAC R309-200-5) [total metals]		Recreational Screening Values [total metals]
		EPA Tap Water RSL (noncarcinogenic)	EPA Tap Water RSL (carcinogenic)	ATSDR Chronic EMEG (child)	ATSDR chronic EMEG (adult)	ASTDR Acute EMEG (based on child value when available)	Maximum Contaminant Level	Action Level	
Hardness	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	7429-90-5	0.012	NA	0.035	0.010	NA	NA	NA	0.00040
Antimony	7440-36-0	0.77	NA	2.1	0.60	NA	1.0	NA	0.024
Arsenic	7440-38-2	7.5	865	21	5.8	1.3	4.5	NA	0.24
Barium	7440-39-3	5.3	NA	14	3.8	NA	10	NA	0.16
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	2.1	NA	3.8	1.0	NA	13	NA	0.043
Cadmium	7440-43-9	2.7	NA	36	9.6	NA	5.0	NA	0.40
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NA	NA	NA	NA	NA	1.2	NA	0.30
Cobalt	7440-48-4	42	NA	NA	NA	NA	NA	NA	0.032
Copper	7440-50-8	0.42	NA	NA	NA	4.76	NA	0.26	0.054
Iron	7439-89-6	0.013	NA	NA	NA	NA	NA	NA	0.00021
Lead	7439-92-1	25	NA	NA	NA	NA	NA	25	0.41
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	0.092	NA	0.11	0.030	NA	NA	NA	0.0013
Mercury	7439-97-6	0.31	NA	NA	NA	NA	0.89	NA	0.0014
Molybdenum	7439-98-7	0.16	NA	0.45	0.12	NA	NA	NA	0.0051
Nickel	7440-02-0	0.96	NA	2.7	0.72	NA	NA	NA	0.021
Potassium	7440-22-4	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	0.33	NA	0.94	0.25	NA	0.66	NA	0.011
Silver	7440-22-4	0.071	NA	0.19	0.05	NA	NA	NA	0.0018
Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	0.48	NA	NA	NA	NA	NA	NA	NA
Thallium	7440-28-0	13	NA	NA	NA	NA	1.3	NA	0.10

Vanadium	7440-62-2	2.1	NA	2.5	0.68	NA	NA	NA	0.029
Zinc	7440-66-6	0.21	NA	0.60	0.16	NA	NA	NA	0.0057

Table 8a. Screening Values for Assessment of Sediment Concentrations

Chemical	CAS Number	Units	Risk-Based Screening Concentrations for Sediment (Soil)							
			EPA Residential RSL (noncarcinogenic)	EPA Residential RSL (carcinogenic)	ATSDR Chronic EMEG (child)	ATSDR chronic EMEG (adult)	ASTDR Acute EMEG (child)	ASTDR Acute EMEG (pica child)	ASTDR Intermediate EMEG (pica child)	Maximum Sediment Concentrations
Aluminum	7429-90-5	mg/kg	7.70E+04	NA	57000	800000	NA	NA	5300	6140
Antimony	7440-36-0	mg/kg	31	NA	NA	NA	NA	NA	NA	4.63
Arsenic	7440-38-2	mg/kg	35	0.68	17	240	290	27	NA	2
Barium	7440-39-3	mg/kg	1.50E+04	NA	11000	160000	NA	NA	1100	191.1
Beryllium	7440-41-7	mg/kg	160	1.60E+03	110	1600	NA	NA	NA	0.291
Cadmium	7440-43-9	mg/kg	71	2100	5.7	80	NA	NA	2.7	0.111
Calcium	7440-70-2	mg/kg	NA	NA	NA	NA	NA	NA	NA	9870
Chromium	7440-47-3	mg/kg	230	NA	NA	NA	NA	NA	NA	5.13
Cobalt	7440-48-4	mg/kg	23	420	NA	NA	NA	NA	53	2.53
Copper	7440-50-8	mg/kg	3100	NA	NA	NA	570	53	53	3.45
Iron	7439-89-6	mg/kg	5.50E+04	NA	NA	NA	NA	NA	NA	6340
Lead	7439-92-1	mg/kg	400	NA	NA	NA	NA	NA	NA	4.48
Magnesium	7439-95-4	mg/kg	NA	NA	NA	NA	NA	NA	NA	2000
Manganese	7439-96-5	mg/kg	1800	NA	NA	NA	NA	NA	NA	198
Mercury	7439-97-6	mg/kg	11	NA	NA	NA	NA	NA	NA	0.00569
Molybdenum	7439-98-7	mg/kg	390	NA	NA	NA	NA	NA	NA	0.43
Nickel	7440-02-0	mg/kg	1.50E+04	1.50E+03	NA	NA	NA	NA	NA	3.6
Potassium	7440-22-4	mg/kg	NA	NA	NA	NA	NA	NA	NA	1665
Selenium	7782-49-2	mg/kg	390	NA	290	4000	NA	NA	NA	3.8
Silver	7440-22-4	mg/kg	390	NA	NA	NA	NA	NA	NA	0.0679
Sodium	7440-23-5	mg/kg	NA	NA	NA	NA	NA	NA	NA	190
Strontium	7440-24-6	mg/kg	4.70E+04	NA	NA	NA	NA	NA	11000	133.1
Thallium	7440-28-0	mg/kg	0.78	NA	NA	NA	NA	NA	NA	0.0677
Vanadium	7440-62-2	mg/kg	390	NA	NA	NA	NA	NA	53	13.5
Zinc	7440-66-6	mg/kg	2.30E+04	NA	17000	240000	NA	NA	1600	18.9

Table 8b. Results of Comparison of Sediment Concentrations to Screening Values.

Analyte	CAS Number	Ratios of SJR Max Value Compared to Risk-based Screening Levels: Risk and Hazards for Sediment						
		EPA Soil RSL (noncarcinogenic)	EPA Soil RSL (carcinogenic)	ATSDR Chronic EMEG (child)	ATSDR chronic EMEG (adult)	ASTDR Acute EMEG (based on child value when available)	ATSDR Acute EMEG (pica child)	ATSDR Intermediate EMEG (pica child)
Aluminum	7429-90-5	0.080	NA	0.11	0.0077	NA	NA	1.2
Antimony	7440-36-0	0.15	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	0.057	2.9	0.12	0.0083	0.0069	0.074	NA
Barium	7440-39-3	0.013	NA	0.017	0.0012	NA	NA	0.17
Beryllium	7440-41-7	0.0018	0.00018	0.0026	0.00018	NA	NA	NA
Cadmium	7440-43-9	0.0016	0.00005	0.019	0.0014	NA	NA	0.041
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	0.022	NA	NA	NA	NA	NA	NA
Cobalt	7440-48-4	0.11	0.0060	NA	NA	NA	NA	0.048
Copper	7440-50-8	0.0011	NA	NA	NA	0.0061	0.065	0.065
Iron	7439-89-6	0.12	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	0.011	NA	NA	NA	NA	NA	NA
Magnesium	7439-95-4	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	0.11	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.00052	NA	NA	NA	NA	NA	NA
Molybdenu	7439-98-7	0.0011	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	0.00024	0.0024	NA	NA	NA	NA	NA
Potassium	7440-22-4	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	0.010	NA	0.013	0.0010	NA	NA	NA
Silver	7440-22-4	0.00017	NA	NA	NA	NA	NA	NA
Sodium	7440-23-5	NA	NA	NA	NA	NA	NA	NA
Strontium	7440-24-6	0.0028	NA	NA	NA	NA	NA	0.012
Thallium	7440-28-0	0.087	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	0.035	NA	NA	NA	NA	NA	0.25
Zinc	7440-66-6	0.0008	NA	0.0011	0.000079	NA	NA	0.012

Table 9. Hazard values Calculated for Ingestion of Fish Tissue.

Analyte	Total Fish Tissue Concentration (mg/kg)	Intake Rate (g/day)	Exposure Frequency (days/year)	Exposure Duration (Year)	Body Weight (kg)	Averaging Time		NC Intake (mg/kg-day)	C Intake (mg/kg-day)	Toxicity Value		Hazard	Risk
						NC (days)	C (days)			NC (mg/kg-day)	C (mg/kg-day)		
Aluminum	16774.64	32	350	30	70	10950	25550	0.00735327	0.003151401	1	NA	0.0074	NA
Barium	867.54	32	350	30	70	10950	25550	0.000380293	0.000162983	0.2	NA	0.0019	NA
Beryllium	0.75	32	350	30	70	10950	25550	3.26592E-07	1.39968E-07	2.00E-	NA	0.00016	NA
Cobalt	4.53	32	350	30	70	10950	25550	1.98559E-06	8.50965E-07	3.00E-	NA	0.0066	NA
Copper	80.28	32	350	30	70	10950	25550	3.51911E-05	1.50819E-05	4.00E-	NA	0.00088	NA
Iron	12504.16	32	350	30	70	10950	25550	0.005481278	0.002349119	7.00E-	NA	0.0078	NA
Lead	10.76	32	350	30	70	10950	25550	4.71501E-06	2.02072E-06	NA	NA	NA	NA
Manganese	289.07	32	350	30	70	10950	25550	0.000126715	5.43066E-05	1.40E-	NA	0.00091	NA
Mercury	2.9	32	350	30	70	10950	25550	1.27072E-06	5.44594E-07	NA	NA	NA	NA
Nitrate-Nitrite-Nitrogen	46.4	32	350	30	70	10950	25550	2.03397E-05	8.71703E-06	NA	NA	NA	NA
Silver	0.13	32	350	30	70	10950	25550	5.88178E-08	2.52076E-08	5.00E-	NA	1.2E-05	NA
Sulfate	1570	32	350	30	70	10950	25550	0.000688219	0.000294951	NA	NA	NA	NA
Strontium	411.56	32	350	30	70	10950	25550	0.000180411	7.73189E-05	0.6	NA	0.00030	NA
Thallium	3.00	32	350	30	70	10950	25550	1.31398E-06	5.63133E-07	1.00E-	NA	0.13	NA
Vanadium	0.93	32	350	30	70	10950	25550	4.07592E-07	1.74682E-07	5.00E-	NA	8.2E-05	NA
Zinc	496.51	32	350	30	70	10950	25550	0.000217648	9.32778E-05	3.00E-	NA	0.00073	NA

Table 10. Metals Accumulation in Soils

Chemical	Maximum Predicted Soil Concentrations from use of SJR water for Irrigation					RSLs	
	Water Concentration (mg/L)	Amount Applied to 1 cm2 x 15 cm depth of Soil in 1 Year (mg/cm3)	Soil Concentration 1 Year through 15 cm depth (mg/kg)	Soil Concentration 10 Years (mg/kg)	Soil Concentration 100 Years (mg/kg)	Residential RSL (mg/kg)	Outdoor Worker RSL (mg/kg)
Aluminum	248.00	7.56E-01	4.67E+02	4.67E+03	4.67E+04	7.70E+04	1.10E+06
Antimony	0.0060	1.83E-05	1.13E-02	1.13E-01	1.13E+00	3.10E+01	4.70E+02
Arsenic	0.0450	1.37E-04	8.47E-02	8.47E-01	8.47E+00	0.68 / 35	4.80E+02
Barium	20.00	6.10E-02	3.76E+01	3.76E+02	3.76E+03	1.50E+04	2.20E+05
Boron	ND	ND	ND	ND	ND	1.60E+04	2.30E+05
Beryllium	0.0533	1.62E-04	1.00E-01	1.00E+00	1.00E+01	1.60E+02	2.30E+03
Cadmium	0.0249	7.59E-05	4.68E-02	4.68E-01	4.68E+00	7.10E+01	9.80E+02
Calcium	4.23	1.29E-02	7.96E+00	7.96E+01	7.96E+02	NA	NA
Chromium	0.1230	3.75E-04	2.31E-01	2.31E+00	2.31E+01	1.20E+05	1.80E+06
Cobalt	0.2540	7.74E-04	4.78E-01	4.78E+00	4.78E+01	2.30E+01	3.50E+02
Copper	0.3330	1.01E-03	6.27E-01	6.27E+00	6.27E+01	3.10E+03	4.70E+04
Iron	0.1810	5.52E-04	3.41E-01	3.41E+00	3.41E+01	5.50E+04	8.20E+05
Lead	0.3690	1.12E-03	6.94E-01	6.94E+00	6.94E+01	4.00E+02	8.00E+02
Magnesium	0.4780	1.46E-03	8.99E-01	8.99E+00	8.99E+01	NA	NA
Manganese	0.0395	1.20E-04	7.43E-02	7.43E-01	7.43E+00	1.80E+03	2.60E+04
Mercury	0.0018	5.39E-06	3.33E-03	3.33E-02	3.33E-01	1.10E+01	4.60E+01
Molybdenum	0.0159	4.84E-05	2.99E-02	2.99E-01	2.99E+00	3.90E+02	5.80E+03
Nickel	0.3750	1.14E-03	7.06E-01	7.06E+00	7.06E+01	1.50E+03	2.20E+04
Potassium	0.0485	1.48E-04	9.13E-02	9.13E-01	9.13E+00	NA	NA
Selenium	0.0330	1.01E-04	6.21E-02	6.21E-01	6.21E+00	3.90E+02	5.80E+02
Silver	0.0067	2.05E-05	1.26E-02	1.26E-01	1.26E+00	3.90E+02	5.80E+02
Sodium	0.3770	1.15E-03	7.09E-01	7.09E+00	7.09E+01	NA	NA
Strontium	0.0057	1.75E-05	1.08E-02	1.08E-01	1.08E+00	4.70E+04	7.00E+05
Thallium	0.0026	7.89E-06	4.87E-03	4.87E-02	4.87E-01	7.80E-01	1.20E+01
Vanadium	0.1780	5.43E-04	3.35E-01	3.35E+00	3.35E+01	3.90E+02	5.80E+03
Zinc	1.25	3.81E-03	2.35E+00	2.35E+01	2.35E+02	2.30E+04	3.50E+05

Water Screening Values from Raisbeck et al 2007 (As, Ba, Mo, Se, Na) and Raisbeck et al 2011 (B, Cd, Cr, Cu, Pb, Hg, Zn). NRCS 2004 for Ca and Mg

Arsenic RSLs: carcinogenic / noncarcinogenic

Table 11. Metals Accumulation in Plants and Comparison to Benchmarks

Chemical	Maximum Predicted Soil Concentrations from Irrigation			Plant Toxicity-based Screening Concentration for Soil (mg/kg)	Ratio of Soil Concentration to Plant Screening Level
	Water Concentration (mg/L)	Amount contained in 1 cm2 x 15 cm depth of Soil in 1 Year (mg/cm3)	Soil Concentration 1 Year (mg/kg)		
Aluminum	248	7.56E-01	472.44	50.00	9.45
Antimony	0.006	1.83E-05	0.01	5.00	0.00
Arsenic	0.045	1.37E-04	0.09	18.00	0.00
Barium	20	6.10E-02	38.10	500.00	0.08
Boron	ND	ND	ND	0.50	NA
Beryllium	0.0533	1.62E-04	0.10	10.00	0.01
Cadmium	0.0249	7.59E-05	0.05	32.00	0.00
Calcium	4.23	1.29E-02	8.06	NA	NA
Chromium	0.123	3.75E-04	0.23	1.00	0.23
Cobalt	0.254	7.74E-04	0.48	13.00	0.04
Copper	0.333	1.01E-03	0.63	70.00	0.01
Iron	0.181	5.52E-04	0.34	NA	NA
Lead	0.369	1.12E-03	0.70	120.00	0.01
Magnesium	0.478	1.46E-03	0.91	NA	NA
Manganese	0.0395	1.20E-04	0.08	220.00	0.00
Mercury	0.00177	5.39E-06	0.00	0.30	0.01
Molybdenum	0.01589	4.84E-05	0.03	2.00	0.02
Nickel	0.375	1.14E-03	0.71	38.00	0.02
Potassium	0.0485	1.48E-04	0.09	NA	NA
Selenium	0.033	1.01E-04	0.06	0.52	0.12
Silver	0.00671	2.05E-05	0.01	560.00	0.00
Sodium	0.377	1.15E-03	0.72	NA	NA
Strontium	0.00573	1.75E-05	0.01	NA	NA
Thallium	0.00259	7.89E-06	0.00	1.00	0.00
Vanadium	0.178	5.43E-04	0.34	2.00	0.17
Zinc	1.25	3.81E-03	2.38	160.00	0.01

ND = Not Detected
NA = Not Available

Shading indicates an exceedance of the screening value

BAFs are for wet-weight plants (ORNL 2018)
Plant concentration (mg/kg) = Soil Concentration * BAF (wet weight)
Screening concentrations are from Efroymson et al., 1997

Table 12. Metals Accumulation in Cattle and Comparison to Benchmarks

Chemical	Maximum Predicted Soil Concentrations from Irrigation			Soil Screening Value (mg/kg)	Ratio of Soil Concentration to Soil Screening Value	Water Screening Value (mg/L)
	Water Concentration (mg/L)	Amount contained in 1 cm2 x 15 cm depth of Soil in 1 Year (mg/cm3)	Soil Concentration 1 Year (mg/kg)			
Aluminum	248	7.56E-01	472.44	NA	NA	NA
Antimony	0.006	1.83E-05	0.01	0.27	0.0423	NA
Arsenic	0.045	1.37E-04	0.09	355.00	0.0002	1.00
Barium	20	6.10E-02	38.10	2000	0.0100	NA
Boron	ND	ND	ND	NA	NA	NA
Beryllium	0.0533	1.62E-04	0.10	2.10E+01	NA	NA
Cadmium	0.0249	7.59E-05	0.05	20.00	0.0024	
Calcium	4.23	1.29E-02	8.06	NA	NA	500.00
Chromium	0.123	3.75E-04	0.23	NA	NA	NA
Cobalt	0.254	7.74E-04	0.48	2.30E+02	NA	NA
Copper	0.333	1.01E-03	0.63	281.00	0.0023	
Iron	0.181	5.52E-04	0.34	NA	NA	NA
Lead	0.369	1.12E-03	0.70	1127.00	0.0006	
Magnesium	0.478	1.46E-03	0.91	4.00E+03	NA	250.00
Manganese	0.0395	1.20E-04	0.08	NA	NA	NA
Mercury	0.00177	5.39E-06	0.00	22.00	0.0002	NA
Molybdenum	0.01589	4.84E-05	0.03	NA	NA	NA
Nickel	0.375	1.14E-03	0.71	1.30E+02	NA	NA
Potassium	0.0485	1.48E-04	0.09	NA	NA	NA
Selenium	0.033	1.01E-04	0.06	6.30E-01	0.0998	NA
Silver	0.00671	2.05E-05	0.01	1.40E+01	0.0009	NA
Sodium	0.377	1.15E-03	0.72	NA	NA	1000.00
Strontium	0.00573	1.75E-05	0.01	NA	NA	NA
Thallium	0.00259	7.89E-06	0.00	NA	NA	NA
Vanadium	0.178	5.43E-04	0.34	NA	NA	NA
Zinc	1.25	3.81E-03	2.38	1600.00	NA	NA
Chloride (1)	55.6	--	--	--	--	1500
Total Nitrate (2)	46.4	--	--	--	--	100
Sulfate (1)	1570	--	--	--	--	500

(1) Water quality value from NRCS 2003
(2) Water screening value is for nitrate (Raisbeck et al. 2007)
NA = Not Available
ND = Not Detected

Table 13. Metals Accumulation in Sheep and Comparison to Benchmarks

Chemical	Maximum Predicted Soil Concentrations from Irrigation			Soil Screening Value (mg/kg)	Ratio of Soil Concentration to Soil Screening Value	Water Screening Value (mg/L)
	Water Concentration (mg/L)	Amount contained in 1 cm2 x 15 cm depth of Soil in 1 Year (mg/cm3)	Soil Concentration 1 Year (mg/kg)			
Aluminum	248	7.56E-01	472.44	NA	NA	NA
Antimony	0.006	1.83E-05	0.01	0.27	4.2E-02	NA
Arsenic	0.045	1.37E-04	0.09	352	2.4E-04	1.00
Barium	20	6.10E-02	38.10	2000	1.9E-02	NA
Boron	ND	ND	ND	NA	NA	NA
Beryllium	0.0533	1.62E-04	0.10	2.10E+01	4.8E-03	NA
Cadmium	0.0249	7.59E-05	0.05	12	4.0E-03	NA
Calcium	4.23	1.29E-02	8.06	NA	NA	500.00
Chromium	0.123	3.75E-04	0.23	NA	NA	NA
Cobalt	0.254	7.74E-04	0.48	2.30E+02	2.1E-03	NA
Copper	0.333	1.01E-03	0.63	86	7.4E-03	NA
Iron	0.181	5.52E-04	0.34	NA	NA	NA
Lead	0.369	1.12E-03	0.70	203	3.5E-03	NA
Magnesium	0.478	1.46E-03	0.91	4.00E+03	2.3E-04	250.00
Manganese	0.0395	1.20E-04	0.08	NA	NA	NA
Mercury	0.00177	5.39E-06	0.00	38	8.9E-05	NA
Molybdenum	0.01589	4.84E-05	0.03	NA	NA	NA
Nickel	0.375	1.14E-03	0.71	1.30E+02	5.5E-03	NA
Potassium	0.0485	1.48E-04	0.09	NA	NA	NA
Selenium	0.033	1.01E-04	0.06	6.30E-01	1.0E-01	NA
Silver	0.00671	2.05E-05	0.01	1.40E+01	9.1E-04	NA
Sodium	0.377	1.15E-03	0.72	NA	NA	1000.00
Strontium	0.00573	1.75E-05	0.01	NA	NA	NA
Thallium	0.00259	7.89E-06	0.00	NA	NA	NA
Vanadium	0.178	5.43E-04	0.34	NA	NA	NA
Zinc	1.25	3.81E-03	2.38	545	4.4E-03	NA
Chloride (1)	55.6	--	--	--	--	1500
Total Nitrate (2)	46.4	--	--	--	--	100
Sulfate (1)	1570	--	--	--	--	500

(1) Water quality value from NRCS 2003

(2) Water screening value is for nitrate (Raisbeck et al. 2007)

NA = Not Available

ND = Not Detected

Table 14. Human Ingestion of Plants and Comparison to Risk-based Screening Values.

Chemical	Maximum Predicted Soil Concentrations from Irrigation					Biota Screening Value (mg/kg)	Hazard Quotient
	Water Concentration (mg/L)	Amount contained in 1 cm2 x 15 cm depth of Soil in 1 Year (mg/cm3)	Soil Concentration 1 Year (mg/kg)	Plant BAF	Concentration in Produce (mg/kg)		
Aluminum	248	7.56E-01	472.44	0.001	4.72E-01	142.00	0.003327
Antimony	0.006	1.83E-05	0.01	0.05	5.72E-04	0.06	0.010
Arsenic	0.045	1.37E-04	0.09	0.01	8.57E-04	0.0003	3.040
Barium	20	6.10E-02	38.10	0.0375	1.43E+00	28.50	0.050
Boron	ND	ND	ND	1	NA	28.50	NA
Beryllium	0.0533	1.62E-04	0.10	0.0025	2.54E-04	0.29	0.001
Cadmium	0.0249	7.59E-05	0.05	0.1375	6.52E-03	0.14	0.047
Calcium	4.23	1.29E-02	8.06	NA	NA	NA	NA
Chromium	0.123	3.75E-04	0.23	0.001875	4.39E-04	NA	NA
Cobalt	0.254	7.74E-04	0.48	0.005	2.42E-03	0.04	0.057
Copper	0.333	1.01E-03	0.63	0.1	6.34E-02	5.70	0.011
Iron	0.181	5.52E-04	0.34	0.001	3.45E-04	99.70	0.000003
Lead	0.369	1.12E-03	0.70	0.01125	7.91E-03	0.05	0.159
Magnesium	0.478	1.46E-03	0.91	0.25	2.28E-01	NA	NA
Manganese	0.0395	1.20E-04	0.08	0.0625	4.70E-03	19.9	0.000236
Mercury	0.00177	5.39E-06	0.00	0.225	7.59E-04	0.02	0.033
Molybdenum	0.01589	4.84E-05	0.03	0.0625	1.89E-03	0.71	0.003
Nickel	0.375	1.14E-03	0.71	0.015	1.07E-02	2.85	0.004
Potassium	0.0485	1.48E-04	0.09	NA	NA	NA	NA
Selenium	0.033	1.01E-04	0.06	0.00625	3.93E-04	0.71	0.001
Silver	0.00671	2.05E-05	0.01	0.1	1.28E-03	0.71	0.002
Sodium	0.377	1.15E-03	0.72	NA	NA	NA	NA
Strontium	0.00573	1.75E-05	0.01	0.625	6.82E-03	85.50	0.000080
Thallium	0.00259	7.89E-06	0.00	0.001	4.93E-06	0.0014	0.003
Vanadium	0.178	5.43E-04	0.34	0.001375	4.66E-04	0.72	0.001
Zinc	1.25	3.81E-03	2.38	0.264	6.29E-01	42.70	0.015

ND = Not Detected
NA = Not Available
Plant concentration (mg/kg) = Soil Concentration * BAF (wet weight)

BAFs are for wet-weight plants (ORNL 2018)

Shaded results indicate that screening level is based on carcinogenic risk. Therefore,

Arsenic risk	3.00E-06
Lead risk	1.60E-07

Table 15. Human Ingestion of Beef and Comparison to Risk-based Screening Values.

Chemical	Maximum Predicted Soil Concentrations from Irrigation						Biota Screening Level (mg/kg)	Hazard Quotient
	Water Concentration (mg/L)	Soil Concentration 1 Year (mg/kg)	Beef transfer coefficient	Tissue concentration from food and soil (Cattle) mg/kg	Tissue Concentration from Water Uptake (Cattle) (mg/kg)	Total Concentration in Cattle (mg/kg)		
Aluminum	248	4.72E+02	0.0015	1.52E+00	2.53E+01	2.69E+01	390.00	6.89E-02
Antimony	0.006	1.14E-02	0.001	3.17E-05	4.09E-04	4.41E-04	0.16	2.82E-03
Arsenic	0.045	8.57E-02	0.002	3.87E-04	6.13E-03	6.52E-03	5.31E-04	1.23E+01
Barium	20	3.81E+01	0.00015	1.49E-02	2.04E-01	2.19E-01	78.00	2.81E-03
Boron	ND	ND	0.0008	NA	NA	NA	78.00	NA
Beryllium	0.0533	1.02E-01	0.001	2.20E-04	3.63E-03	3.85E-03	0.78	4.94E-03
Cadmium	0.0249	4.74E-02	0.00055	1.02E-04	9.33E-04	1.03E-03	0.39	2.65E-03
Calcium	4.23	8.06E+00	NA	NA	NA	NA	NA	NA
Chromium	0.123	2.34E-01	0.0055	2.78E-03	4.61E-02	4.89E-02	NA	NA
Cobalt	0.254	4.84E-01	0.02	2.12E-02	3.46E-01	3.67E-01	0.12	3.14E+00
Copper	0.333	6.34E-01	0.01	2.17E-02	2.27E-01	2.49E-01	15.60	1.59E-02
Iron	0.181	3.45E-01	0.02	1.48E-02	2.47E-01	2.61E-01	273.00	9.58E-04
Lead	0.369	7.03E-01	0.0004	6.40E-04	1.01E-02	1.07E-02	0.09	1.14E-01
Magnesium	0.478	9.11E-01	0.005	2.43E-02	1.63E-01	1.87E-01	NA	NA
Manganese	0.0395	7.52E-02	0.0004	8.83E-05	1.08E-03	1.16E-03	54.60	2.13E-05
Mercury	0.00177	3.37E-03	0.25	4.23E-03	3.02E-02	3.44E-02	0.06	5.51E-01
Molybdenum	0.01589	3.03E-02	0.006	5.33E-04	6.50E-03	7.03E-03	1.95	3.60E-03
Nickel	0.375	7.14E-01	0.006	9.96E-03	1.53E-01	1.63E-01	7.80	2.09E-02
Potassium	0.0485	9.24E-02	NA	NA	NA	NA	NA	NA
Selenium	0.033	6.29E-02	0.015	2.08E-03	3.37E-02	3.58E-02	1.95	1.84E-02
Silver	0.00671	1.28E-02	0.003	1.31E-04	1.37E-03	1.50E-03	1.95	7.71E-04
Sodium	0.377	7.18E-01	NA	NA	NA	NA	NA	NA
Strontium	0.00573	1.09E-02	0.0003	3.33E-05	1.17E-04	1.50E-04	234.00	6.43E-07
Thallium	0.00259	4.93E-03	0.04	4.23E-04	7.06E-03	7.48E-03	0.004	1.92E+00
Vanadium	0.178	3.39E-01	0.0025	1.82E-03	3.03E-02	3.21E-02	1.97	1.63E-02

Zinc	1.25	2.38E+00	0.1	1.31E+00	8.52E+00	9.83E+00	117.00	8.40E-02

ND = Not Detected

NA = Not Available

Beef Transfer Coefficients from ORNL 2018.

Assumptions:

Soil ingestion rate and food ingestion rate from Ford and Beyer 2104, and water ingestion rates for beef cattle and sheep are from NRCS 2003.

Tissue concentration from food and soil ingestion calculation:: [(Ingestion rate food*concentration in plants + Concentration in soil * Ingestion Rate soil)*BAF]

Tissue concentration from water ingestion calculation:: (Water ingestion * water concentration)*BAF

Beef:

Soil Ingestion 2.13

Food Ingestion 12.84 weighted dry to wet conversion factor of 0.888

Water Ingestion 68.14 for grains (Baes 1984) used to convert food intake to wet weight

Shaded results indicate that screening level is based on carcinogenic risk. Therefore,

Arsenic risk 1.23E-05

Lead risk 1.10E-07

Attachment 1. Bioaccumulation Factors for Beef and Plants (ORNL 2018)

ANALYSIS	CASNUM	Beef Transfer Coefficient (day/kg)	Soil-to-Wet Plant Uptake
Aluminum	7429-90-5	0.0015	0.001
Antimony (metallic)	7440-36-0	0.001	0.05
Arsenic, Inorganic	7440-38-2	0.002	0.01
Barium	7440-39-3	0.00015	0.0375
Beryllium and compounds	7440-41-7	0.001	0.0025
Boron And Borates Only	7440-42-8	0.0008	1
Cadmium (Diet)	7440-43-9	0.00055	0.125
Cadmium (Water)	7440-43-9	0.00055	0.1375
Chromium(III), Insoluble Salts	16065-83-1	0.0055	0.001875
Cobalt	7440-48-4	0.02	0.005
Copper	7440-50-8	0.01	0.1
Iron	7439-89-6	0.02	0.001
Lead and Compounds	7439-92-1	0.0004	0.01125
Magnesium	7439-95-4	0.005	0.25
Manganese (Diet)	7439-96-5	0.0004	0.0625
Manganese (Non-diet)	7439-96-5	0.0004	0.0625
Mercury (elemental)	7439-97-6	0.25	0.225
Molybdenum	7439-98-7	0.006	0.0625
Nickel Soluble Salts	7440-02-0	0.006	0.015
Selenium	7782-49-2	0.015	0.00625
Silver	7440-22-4	0.003	0.1
Strontium, Stable	7440-24-6	0.0003	0.625
Thallium (Soluble Salts)	7440-28-0	0.04	0.001
Vanadium	NA	0.0025	0.001375
Zinc and Compounds	7440-66-6	0.1	0.264

Attachment 2. Screening Levels for Biota (ORNL 2018)

Default
Farmer Equation Inputs for Contaminated Food Products

Variable	Value
THQ (target hazard quotient) unitless	1
TR (target cancer risk) unitless	1.0E-6
LT (lifetime - resident) yr	70
IRF_{far-a} (fruit intake rate - adult) mg/day	176800
IRF_{far-c} (fruit intake rate - child) mg/day	68100
$IFF_{far-adj}$ (age-adjusted fruit intake rate) mg-year/kg-day	35833000
IRV_{far-a} (vegetable intake rate - adult) mg/day	125700
IRV_{far-c} (vegetable intake rate - child) mg/day	41700
$IFV_{far-adj}$ (age-adjusted vegetable intake rate) mg-year/kg-day	24535875
IRB_{far-a} (beef intake rate - adult) mg/day	178000
IRB_{far-c} (beef intake rate - child) mg/day	40100
$IFB_{far-adj}$ (age-adjusted beef intake rate) mg-year/kg-day	32091500
IRD_{far-a} (dairy intake rate - adult) mg/day	445600
IRD_{far-c} (dairy inake rate - child) mg/day	349500
$IFD_{far-adj}$ (age-adjusted dairy intake rate) mg-year/kg-day	115213000
BW_{far-a} (body weight - adult) kg	80
BW_{far-c} (body weight - child) kg	15
ED_{far-a} (exposure duration - adult) yr	34
ED_{far-c} (exposure duration - child) yr	6
EF_{far-c} (exposure frequency - child) day/yr	350
EF_{far-a} (exposure frequency - adult) day/yr	350
$CF_{far-produce}$ (contaminated intake fraction) unitless	1
$CF_{far-beef}$ (contaminated intake fraction - beef) unitless	1
$CF_{far-dairy}$ (contaminated intake fraction - dairy) unitless	1
$MLF_{pasture}$ (pasture plant mass loading factor) unitless	0.25
$MLF_{produce}$ (produce plant mass loading factor) unitless	0.0135

Output generated 14JAN2018:18:34:53

Default
Farmer PRG for Contaminated Food Products

Chemical	CAS Number	Mutagen?	VOC?	Chronic RfD (mg/kg-day)	Chronic RfD Ref	Ingestion SF (mg/kg-day)$^{-1}$	SFO Ref	Produce Ingestion PRG TR=1.0E-6 (mg/kg)	Dairy Ingestion PRG TR=1.0E-6 (mg/kg)	Beef Ingestion PRG TR=1.0E-6 (mg/kg)	Produce Ingestion PRG HQ=1 (mg/kg)	Dairy Ingestion PRG HQ=1 (mg/kg)	Beef Ingestion PRG HQ=1 (mg/kg)
Aluminum	7429-90-5	No	No	1.00E+00	P	-		-	-	-	1.42E+02	4.48E+01	3.90E+02
Antimony (metallic)	7440-36-0	No	No	4.00E-04	I	-		-	-	-	5.70E-02	1.79E-02	1.56E-01
Arsenic, Inorganic	7440-38-2	No	No	3.00E-04	I	1.50E+00	I	2.82E-04	1.48E-04	5.31E-04	4.27E-02	1.34E-02	1.17E-01
Barium	7440-39-3	No	No	2.00E-01	I	-		-	-	-	2.85E+01	8.95E+00	7.80E+01
Beryllium and compounds	7440-41-7	No	No	2.00E-03	I	-		-	-	-	2.85E-01	8.95E-02	7.80E-01
Boron And Borates Only	7440-42-8	No	No	2.00E-01	I	-		-	-	-	2.85E+01	8.95E+00	7.80E+01
Cadmium (Diet)	7440-43-9	No	No	1.00E-03	I	-		-	-	-	1.42E-01	4.48E-02	3.90E-01
Calcium	7440-70-2	No	No	-		-		-	-	-	-	-	-
Chromium Salts	NA	No	No	-		-		-	-	-	-	-	-
Cobalt	7440-48-4	No	No	3.00E-04	P	-		-	-	-	4.27E-02	1.34E-02	1.17E-01
Copper	7440-50-8	No	No	4.00E-02	H	-		-	-	-	5.70E+00	1.79E+00	1.56E+01
Iron	7439-89-6	No	No	7.00E-01	P	-		-	-	-	9.97E+01	3.13E+01	2.73E+02
Lead and Compounds	7439-92-1	No	No	-		8.50E-03	C	4.98E-02	2.61E-02	9.37E-02	-	-	-
Magnesium	7439-95-4	No	No	-		-		-	-	-	-	-	-
Manganese (Diet)	7439-96-5	No	No	1.40E-01	I	-		-	-	-	1.99E+01	6.27E+00	5.46E+01
Mercury (elemental)	7439-97-6	No	Yes	1.60E-04	C	-		-	-	-	2.28E-02	7.16E-03	6.24E-02
Molybdenum	7439-98-7	No	No	5.00E-03	I	-		-	-	-	7.12E-01	2.24E-01	1.95E+00
Nickel Soluble Salts	7440-02-0	No	No	2.00E-02	I	-		-	-	-	2.85E+00	8.95E-01	7.80E+00
Potassium	7440-09-7	No	No	-		-		-	-	-	-	-	-
Selenium	7782-49-2	No	No	5.00E-03	I	-		-	-	-	7.12E-01	2.24E-01	1.95E+00
Silver	7440-22-4	No	No	5.00E-03	I	-		-	-	-	7.12E-01	2.24E-01	1.95E+00
Sodium	7440-23-5	No	No	-		-		-	-	-	-	-	-
Strontium, Stable	7440-24-6	No	No	6.00E-01	I	-		-	-	-	8.55E+01	2.69E+01	2.34E+02
Thallium (Soluble Salts)	7440-28-0	No	No	1.00E-05	P	-		-	-	-	1.42E-03	4.48E-04	3.90E-03
Vanadium and Compounds	7440-62-2	No	No	5.04E-03	S	-		-	-	-	7.18E-01	2.26E-01	1.97E+00
Zinc and Compounds	7440-66-6	No	No	3.00E-01	I	-		-	-	-	4.27E+01	1.34E+01	1.17E+02

Output generated 14JAN2018:18:34:53